FINAL HYDRAULIC REPORT

for

LOWER SILVER CREEK
REACH 3

SAN JOSE, CALIFORNIA

Prepared

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for

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COYOTE WATERSHED PROGRAM
LOWER SILVER CREEK REACH 3
FINAL HYDRAULIC REPORT

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CHAPTER 1
OVERVIEW

This Final Hydraulic Report has been prepared for Psomas to document hydraulic and sediment transport analyses in Lower Silver Creek Reach 3 (Coyote Watershed Project No. 4026-03; operating under the auspices of the Santa Clara Valley Water District.) This report describes Lower Silver Creek between McKee Road and Interstate 680 in San Jose, California. Hydraulic modeling is based upon the following construction documents:

Map and Construction Plan for Lower Silver Creek
Flood Protection and Creek Restoration Project Reach 3, Phase 1:
McKee Road to Alum Rock Ave
Coyote Watershed Project No 4026-01
July 15, 2004

Map and Construction Plan for Lower Silver Creek
Flood Protection and Creek Restoration Project Reach 3, Phase 2:
Upstream of Lausett Avenue (Station 100+00) to Interstate 680
Coyote Watershed Project No 4026-01
April 6, 2004

Map and Construction Plan for Lower Silver Creek
Flood Protection and Creek Restoration Project Reach 3, Phase 3, Volume II of IV:
Downstream of Alum Rock Ave (Station 86+00) to Upstream of Lausett Ave (Station 100+00)
Coyote Watershed Project No 4026-01
July 15, 2004 (unsigned)

PROJECT OBJECTIVES

The basic objective of the Lower Silver Creek Reach 3 Improvement Project is to provide a level of flood protection along Lower Silver Creek consistent with National Resources Conservation Service (NRCS) and Santa Clara Valley Water District (District) policies, and the policies of the Federal Emergency Management Agency (FEMA) as administered through the National Flood Insurance Program (NFIP). District and NFIP regulations define the “base flood” as a flood having a one percent chance of being equaled or exceeded in any given year. Although the primary project objective is to provide a level of flood protection along Lower Silver Creek meeting District, NRCS and FEMA standards, additional project objectives include:

- balancing flood reduction with environmental restoration, community beautification, and recreational opportunities.
- providing efficient and cost-effective flood control maintenance to ensure that the District is able to maintain design system performance in the future;
- allowing for more natural geomorphic processes in Lower Silver Creek; and
- engendering community support for the proposed project.

SCOPE OF HYDRAULIC REPORT

Within this hydraulic report, design one-percent discharges are estimated in Reach 3 using a watershed model built under separate contract with the District. Steady-state backwater analyses have been made to evaluate proposed channel improvements over a range of possible roughness conditions. Hydraulic stability and sediment transport analyses are made to assess long-term channel stability, potential sediment accumulations, and bank slope protection.

BACKGROUND

Readers are referred to *Coyote Watershed Program Lower Silver Creek Improvement Project Final Hydraulic Report* prepared in March 2002 by Schaaf & Wheeler for a complete background of the Lower Silver Creek Improvement Project. (Reach 3 is an intermediate improvement reach of Lower Silver Creek as it drains to Coyote Creek in east San Jose.) The project hydraulic report includes an evaluation of the hydrologic and hydraulic regime within the Lower Silver Creek watershed from Lake Cunningham to Coyote Creek; defines design criteria; and presents preliminary water surface profiles for project reaches 1 through 6.

CREEK RESTORATION PROJECT ELEMENTS

In 1998, the NRCS prepared a set of conceptual drawings for the Lower Silver Creek Improvement Project. The NRCS only performed preliminary hydraulic calculations using methods that did not factor in backwater effects from Coyote Creek or other channel transitions. No water surface profiles or hydraulic models are available to the District for verification of the NRCS plan, and hydraulic analyses were not performed at existing bridges.

Channel Improvements

The Program refined and enhanced the original NRCS plan to reduce the amount of concrete lining, utilize more natural and environmentally sensitive materials and configurations, provide for more natural channel geomorphologic processes, improve maintenance, and allow greater public access to the creek. As a result, the channel configuration has been revised, including the acquisition of additional rights-of-way to facilitate channel enhancements. Hydraulic analyses are based upon construction plans for channel geometry between McKee Road and Alum Rock Avenue (Phase I: March 26, 2003); and for channel improvements between Alum Rock Avenue and Interstate 680 (Phase II: August 29, 2003).

Channel Reach Designations

Throughout this report, the following reach designations are used:

Reach 3A	McKee Road to Checkers Drive
Reach 3B	Checkers Drive to Alum Rock Avenue
Reach 3C	Alum Rock Avenue to San Antonio Street
Reach 3D	San Antonio Street to Kammerer Avenue
Reach 3E	Kammerer Avenue to Interstate 680

HYDRAULIC PERFORMANCE

Channel improvements will enable the one-percent water surface profile to be carried at or below the natural bank elevation throughout most of the project reach. To meet FEMA and NRCS freeboard criteria, some reaches require additional protection in the form of floodwalls. Floodwall heights greater than three feet above natural ground are limited to about 850 feet just upstream of McKee Road on the bank opposite Plata Arroyo Park in Reach 3A.

The Alum Rock Avenue Bridge and Sunset Avenue Culvert will be replaced and modified, respectively, in addition to Reach 3 channel improvements. The proposed bridge replacement and culvert modification are described herein, and proven to be hydraulically adequate.

Sediment Transport

Within much of the project reach, the channel bottom will be unlined and subject to erosive velocity. Some of the eroded material will move downstream, and where channel velocity decreases, may accumulate as sediment deposits. Reach 3 of Lower Silver Creek will be excavated through cohesive material such as clay, silty clay, and sandy clay. In areas with relatively low average channel velocities – Reaches 3A, 3C, 3D, and 3E – erosion protection is provided by some combination of vegetated channel banks, gabions, and emergent wetland vegetation over an earthen bottom. However, tractive force analyses show that *if vegetation does not become well established to provide erosion protection, the channel bed will be subject to erosive velocities and could scour in the design flood event*. Channel reaches with higher velocities – Reach 3B – are concrete lined.

Sediment transport capacity from Interstate 680 downstream to Alum Rock Avenue is generally greater than sediment transport capacity immediately upstream of Interstate 680, where a five-foot deep sediment basin is provided to trap accumulated sediment for periodic removal in Reach 4. Consequently these reaches are subject to erosion more than deposition. The greatest potential for scour within Reach 3 occurs between San Antonio Street and Sunset Avenue in Reach 3C. The channel reach between Sunset and Alum Rock can generally transport all of the sediment delivered to it, while sediment transport capacity is lower downstream of Alum Rock due to backwater from the McKee Road culvert. Hence if the channel is carrying sediment from upstream, Reach 3A in particular will tend toward deposition rather than scour. Historically, the McKee Road culvert and channel reaches immediately upstream have been subject to accumulations of sediment.

CHAPTER 2
PROJECT BACKGROUND

This chapter introduces the Lower Silver Creek Reach 3 project area, summarizes previous project plans, and introduces the Program's project objectives.

Reach 3 is the most varied of all reaches in terms of channel configuration. From McKee Road through the Plata Arroyo Park (Reach 3A), the channel is excavated from native materials with substantial creek and bank vegetation. An earthen levee provides flood protection to residents on the east bank, while the park itself floods during significant runoff events. Above the park, the trapezoidal channel is concrete lined upstream almost to San Antonio Street. The excavated channel is more natural as it passes Mayfair Park and Mathson Junior High before ending at Interstate 680.

Photos 1 and 2. U/S Face of McKee/King Culvert: Note sediment deposits immediately upstream of bridge.

←Photo 3. Sediment Inside Eastern McKee Road Culvert Barrel.

Photo 4. Reach 3A (July 2000)

Photo 5. Reach 3A (May 2001)

Photo 6. End Reach 3A

Photo 7. Reach 3B

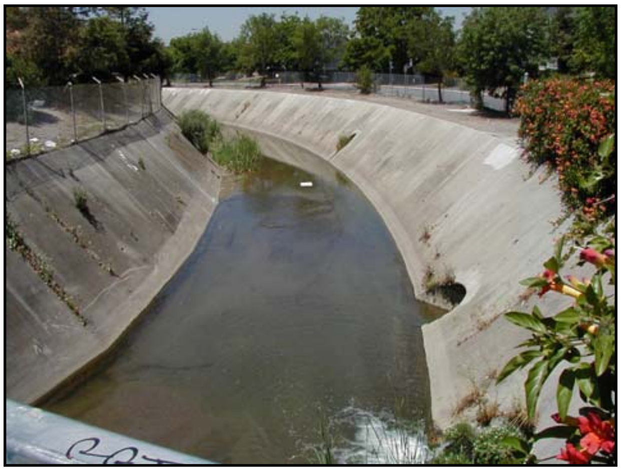


Photo 8. Reach 3C: Trapezoidal lining will be eliminated in much of this reach.

Photo 9. Reach 3D: Downstream of San Antonio

Photo 10. San Antonio Street: Downstream Face of Bridge, which will remain intact.↓

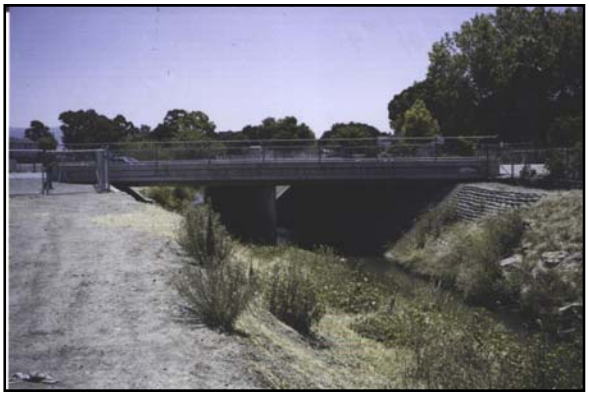


Photo 11. Reach 3D: US from San Antonio Bridge.

Photo 12. Reach 3E: Lower Silver Creek taken from Kammerer Bridge looking DS in Mayfair Park→

Photo 13. Reach 3F: From I680 (below)
Photo 14. Reach 3F: From Kammerer (below, right)

PREVIOUS PLANNING STUDIES

A planning study prepared by the District in 1976 proposed to provide a concrete-lined trapezoidal channel for most of Lower Silver Creek between Highway 101 and Cunningham Avenue. This plan was abandoned in the early 1980s in favor of the NRCS (formerly SCS) plan of 1983. The original watershed plan examined five non-structural and three structural measures to provide one-percent flood protection. Of these eight plans, three were formulated for further alternatives analysis.

1) No Project;

2) Non-structural Floodplain Protection; and

3) Channel Enlargement and Floodproofing.

1998 NRCS Plan

In 1998 the NRCS developed a major update to their 1983 plan. They investigated new alternatives in an attempt to minimize the lineal feet of proposed concrete channel and incorporate more environmentally sensitive design elements. After examining eleven more non-structural and structural measures, three new alternatives were selected for further study and refinement:

1) Geomorphic Stream Restoration with Detention Basins;

2) Geomorphic Stream Restoration with Diversion Channels; and

3) Hybrid Vegetated Block Wall Channel.

The third alternative was recommended, and has been carried forward as the basis of design for Reach 3, refined as described in Chapter 5 of this report.

PROJECT OBJECTIVES

The basic objective of the Lower Silver Creek Reach 3 Improvement Project is to provide a level of flood protection along Lower Silver Creek consistent with NRCS and District policies, and the policies of the Federal Emergency Management Agency (FEMA) as administered through the National Flood Insurance Program (NFIP).

District and NFIP regulations define the “base flood” as a flood having a one percent chance of being equaled or exceeded in any given year. Often this is referred to as a “one-percent” or “100-year” flood. This should not be confused with a flood that *will* occur once every one hundred years, but one that might occur once every one hundred years *on the average* over a very long period of time. In fact, over the life of a 30-year mortgage, there is a 26 percent chance of experiencing a flood equal or greater in magnitude than the base flood as demonstrated by Table 2-1. These probability concepts may have an impact on construction staging, particularly the timing of bridge replacements and protecting newly the excavated channel prior to the re-establishment of vegetation.

Table 2-1: Relative Risk of Various Flood Events

	5-year	**10-year**	**100-year**
Annual risk of event	20%	10%	1%
Risk of at least one event in 5 years	67%	41%	5%
Risk of at least one event in 10 years	89%	65%	10%
Risk of at least one event in 30 years	99.88%	96%	26%
Risk of at least one event in 50 years	99.998%	99%	39%
Risk of at least one event in 100 years	really high	99.997%	63%

Other Project Goals

Although the primary project objective is to provide a level of flood protection along Lower Silver Creek meeting District, NRCS and FEMA standards, additional project objectives include:

- balancing flood reduction with environmental restoration, community beautification, and recreational opportunities.
- providing efficient and cost-effective flood control maintenance to ensure that the District is able to maintain design system performance in the future;
- allowing for more natural geomorphic processes in Lower Silver Creek; and
- engendering community support for the proposed project.

CHAPTER 3

WATERSHED HYDROLOGY

This chapter summarizes hydrologic analyses within the Lower Silver Creek and Coyote Creek watersheds undertaken for this project. Design discharges are presented, and coincident starting water surface elevations at Coyote Creek are established for design. A full watershed model is provided in the Lower Silver Creek Final Hydraulic Report for readers interested in more detail.

DESIGN DISCHARGE ESTIMATION

Runoff at key design points along Lower Silver Creek for various storm events are summarized in Table 3-1, based on the Program's watershed model prepared under separate contract. The design 100-year flow in Reach 3 varies from 4,210 cfs to 4,340 cfs.

Table 3-1: Design Discharges on Lower Silver Creek

	Discharge (cfs)			
Location	**2-year**	**5-year**	**10-year**	**100-year**
Lake Inflow	610	2,040	3,400	5,060
Cunningham Avenue	610	2,040	2,650	2,810
S. Babb Creek	680	2,420	3,310	3,670
N. Babb Creek	780	2,630	3,640	4,160
Interstate 680	780	2,650	3,670	4,210
Alum Rock Avenue	810	2,730	3,780	4,340
Miguelita Creek	890	2,940	4,160	4,920
Highway 101	940	3,050	4,360	5,220
Coyote Creek	940	3,050	4,360	5,220

COINCIDENCE WITH COYOTE CREEK

Water surfaces elevations, particularly in the lower reaches of Lower Silver Creek, can be directly influenced by conditions in Coyote Creek at the confluence. Backwater calculations presented in the Program Final Hydraulic Report indicate that one-percent backwater effects from Coyote Creek dissipate downstream of Highway 101 in Reach 1, so Reach 3 water surface profiles are not affected by Coyote Creek.

CHAPTER 4

DESIGN CRITERIA

This chapter documents hydraulic parameters used to design channel improvements for Lower Silver Creek Reach 3, which are consistent with design criteria in other reaches of the improvement project. Hydraulic parameters discussed include:

1) channel roughness;
2) bridge modeling techniques and transition losses;
3) freeboard requirements; and
4) maintenance criteria.

CHANNEL ROUGHNESS

In one-dimensional open channel flow analysis as performed using HEC-RAS, a single parameter known as “Manning’s n” is used to represent the retarding forces to flow imposed by the channel. Values for “n” are published in the literature, and in the absence of high water marks with which to calibrate stream reaches with known discharge, are often relied upon for channel design. When selecting roughness values for design, it is important to remember that in one-dimensional flow, Manning’s “n” accounts for the flow resistance due to a host of hydraulic phenomena beyond boundary shear. Other factors may include the effects of eddies, cross-waves, super-elevation, bed forms, sediment and debris.

Roughness Elements

Several sources have been used to estimate roughness factors for water surface profile determination within Lower Silver Creek. These include “n” values published by Henderson (1966) and Chow (1959), engineering judgment, and procedures outlined by the Corps of Engineers for roughness values within concrete lined channels (ASCE, 1995). Table 4-1 summarizes design channel roughness values of various channel elements proposed for use in hydraulic analysis.

Given the uncertainty in “n” value selection, a range of “n” values is used to examine channel performance. Lower values tend to increase channel velocity, which may be important in terms of scour or wave formation. Higher values tend to maximize water depth, and will generally set freeboard requirements. For vegetal channel linings, typical “n” values for temporary erosion control materials will be used to evaluate high flow velocities. Manning’s “n” values that are contingent upon maintenance conditions are so indicated.

Table 4-1: Manning's "n" Values for Hydraulic Analysis

Element	**High "n" for depth**	**Low "n" for velocity**
Concrete Lining	0.018	0.011
Bare Earth	0.030	0.020
Erosion Control Blanket	---	0.020
Gravel Maintenance Road	0.025	0.020
Vegetated Gabion Mattresses or Walls	0.045	0.030
Vegetated Block Slopes	0.045	0.030
Grass Lining (Mowed to <12")	0.040	0.020
Emergent Wetland (Maintained)	0.050	0.020
Grass Lining (No maintenance)	0.060	0.020
Emergent Wetland (No maintenance)	0.100	0.020
Trees, shrubs, vines (No maintenance)	0.150	0.020
Rock Slope Protection	$0.034(d_{50})^{1/6}$	$0.034(d_{50})^{1/6}$

Composite Roughness Calculations

By design, the roughness along the wetted perimeter of Lower Silver Creek varies across each cross section. For instance, at an individual cross section location, the channel might contain elements of emergent wetland, grass lining, trees, shrubs, and a maintenance road. To compute water surface elevations in a channel with variable roughness using a one-dimensional model (i.e. with a mean velocity), it is necessary to estimate an effective (composite) roughness value for each cross section. Flow velocities vary across the channel due to variation in both the flow depth and roughness from one channel element to the next. To calculate mean flow velocity without actually subdividing each channel section, several methods have been suggested in the literature for estimating a composite roughness value within non-uniform channels.

HEC-RAS calculates a composite "n" value based on an assumption that average velocities within each channel element are equal and equivalent to the mean channel velocity as a whole. (HEC, 1998) Since this is not the case for Lower Silver Creek, a more appropriate method that weights "n" by channel conveyance is used herein.

As described by Chow (1959), Lotter assumed that the total discharge in each section is equal to the sum of the discharges of individual areas subdivided by roughness (i.e. conservation of mass). The resultant equivalent roughness coefficient formula, consistent with US Army Corps of Engineers engineer manual EM 1110-2-1601, is provided by Chow as Equation 6-19:

$$n = \frac{P\ R^{5/3}}{\sum\left(\frac{P_N\ R_N^{5/3}}{n_N}\right)} = \frac{P\ R^{5/3}}{\frac{P_1\ R_1^{5/3}}{n_1} + \frac{P_2\ R_2^{5/3}}{n_2} + \ldots + \frac{P_N\ R_N^{5/3}}{n_N}}$$

where n = composite roughness coefficient for cross section
P = total wetted perimeter of cross section (feet)
R = total hydraulic radius of cross section (feet)
P_i = wetted perimeter of cross section element i (feet)
R_i = hydraulic radius of cross section element i (feet)
n_i = Manning's roughness coefficient for cross section element i

Appendix C details the calculation of composite roughness values for each channel sub-reach.

Because the distribution of velocities is not uniform across channel sections, the velocity head is generally greater than the value computed when using the mean velocity. (Chow, 1959) The actual velocity head is represented by the term $\alpha V^2/2g$; where V is the mean velocity, and α is known as the energy coefficient, velocity coefficient, or Coriolis coefficient, determined from:

$$\alpha = \frac{\int v^3\, dA}{V^3 A}$$

where α = velocity coefficient (dimensionless)
v = velocity within an individual channel element (feet per second)
V = mean channel velocity (feet per second)
A = cross sectional area (square feet)

BRIDGE MODELING

In addition to the energy required to overcome channel resistance, structures such as bridges and culverts also cause energy losses, which can result in a raised water surface profile. Methods provided by HEC-RAS for analyzing bridges and culverts under low flow and pressurized conditions are employed in the backwater computations.

Several methods are available through HEC-RAS to compute energy losses through a bridge. The "energy only" or standard step method handles a bridge section without piers in the same manner as a natural river section, except that the area between the low chord of the bridge (soffit) and the top of road is subtracted from the total cross-sectional area, and the wetted perimeter is increased where water is in contact with the bridge. Increased frictional resistance due to the added wetted perimeter is included in the energy loss through the structure.

When bridge piers are present, either conservation of momentum may be applied by using a coefficient of drag, or Yarnell's method may be used for subcritical "Class A" low flow through the bridge. Table 4-2 provides proposed drag coefficients for the momentum method and pier shape coefficients for Yarnell's low flow bridge loss calculations, respectively.

Table 4-2: Pier Coefficients

Pier Shape	**Drag Coefficient**	**Pier Coefficient**
Semicircular Nose and Tail	1.33	0.90
Multiple Cylinders	1.33	1.00
Triangular Nose and Tail	2.00	1.05
Square Nose and Tail	2.00	1.25

When the computed water surface elevation is above the bridge soffit, a "pressure/weir" feature can compute losses through the structure for pressure (orifice) flow, weir flow over the top, or a combination of both. (For Lower Silver Creek, weir flow over bridges is not allowed.) Changes to the water surface profile resulting from the bridge are calculated based on hydraulic formulae that estimate the change in energy and water surface elevation through the bridge. Other hydraulic routines are also available to perform the same function for standard culvert shapes.

Coefficients of discharge for orifice flow during bridge pressurization are evaluated on a case-by-case basis using the guidelines outlined in Table 4-3. When an orifice is located close to the bottom or bank of the channel, the approaching flow is guided so that the orifice contraction is suppressed on those sides of the orifice close to such guides. Clear span bridges across trapezoidal or U-frame (rectangular) channels are examples of orifices contracted on three sides.

Table 4-3: Orifice Coefficients

Condition	Orifice Coefficient
Orifice in Thick Wall (typical bridge)	0.80
Submerged, square-edged	0.80
Submerged, well-rounded	0.90
Increase in C per number of contracted sides	0.04

Transition Losses

An energy loss also takes place just upstream and downstream from each structure as flow contracts and expands into and out of the bridge or culvert. The following contraction and expansion coefficients for channel transitions are used in the hydraulic models (Table 4-4). Wherever turbulent conditions create the potential for energy loss, contraction and expansion coefficients are increased. Other transitions include channel bends, resting pools, and maintenance access ramps.

Table 4-4: Expansion and Contraction Coefficients

Transition Type	Contraction	Expansion	Source
Gradual	0.1	0.3	HEC
Warped	0.1	0.2	Chow
Wedge	0.3	0.5	Chow
Square End	0.3	0.75	Chow
Abrupt	0.6	0.80	HEC

FREEBOARD

The use of design "freeboard" provides a measure of safety that compensates for the many unknown and difficult-to-quantify parameters that affect the calculation of flood elevations. These factors include uncertainty in rainfall data, soil loss parameters, watershed urbanization, wave action, debris at bridge openings, and general uncertainties in hydrologic and hydraulic procedures. Freeboard is usually expressed in terms of feet above the design base flood elevation. To meet FEMA standards, freeboard is necessary whenever a levee system, including structural floodwalls, is used to provide flood protection.

When mapping flood-prone areas, FEMA only recognizes those levee systems meeting their criteria, which includes a minimum three feet of freeboard whenever the design one-percent water surface elevation is carried above the natural ground elevation. An additional six inches of freeboard (3.5 feet above the water surface) is required at the upstream end of the levee / floodwall system, tapering to the minimum freeboard of 3.0 feet at the downstream end of the levee. For this reason, the District has adopted a uniform freeboard criterion of 3.5 feet. An additional foot of freeboard (4.0 feet above the water surface) must be provided within 100 feet of each side of any structure, such as a bridge or culvert.

FEMA does not impose a freeboard requirement when the base flood can be carried without the use of a levee system. The District, however, does have additional project freeboard requirements for design projects (SCVWD, 1994), which can be more restrictive than FEMA's actuarial criteria. Table 4-5 provides the respective criteria, where "D" refers to the estimated depth of flow in feet, and "V" is flow velocity in feet per second.

Table 4-5: Freeboard Requirements

Situation	FEMA (Feet)	District (Feet)
Water Surface Above Natural Bank Elevation	3.0	3.5
Water Surface Above Bank within 100 feet of Structure	4.0	4.0
Water Surface Below Natural Bank Elevation	N/A	$0.2(D + V^2/2g)$
Minimum Freeboard	N/A	1.0

District criteria for water surfaces below natural bank elevation are based on NRCS guidelines. Recently the NRCS has approved the use of a slightly different formula for its freeboard criterion within incised channels; that is, where the design water surface is carried below the natural bank. The velocity head term has been omitted, leaving the required freeboard within an incised channel as the minimum of one foot or 0.2D, where D is flow depth. The NRCS has also approved a District-proposed method of weighting depth based upon flow conveyance, as stated in an October 31, 2001 memorandum from NRCS Design Staff Leader Bill Ward, P.E.:

> "[The NRCS] has determined that using a composite freeboard based on weighting the conveyance for individual channel areas within a section is a good approach for multi-staged channels and recommend[s] its use in these cases. To meet NRCS criteria you can simply use this procedure and replace the energy head with depth. Of course the minimum freeboard should not be less than one foot, and other requirements for freeboard (super-elevation, unstable range) are on top of the calculated composite freeboard."

The effect of differing conveyance within multi-staged channels is already accounted for by the calculation of composite roughness and velocity coefficients to produce an average water surface elevation. It is also recommended that the minimum freeboard be based on the hydraulic depth, which is the depth of an equivalent rectangular shaped channel (flow area divided by top width), and produces a weighted depth similar to the District's composite freeboard calculation. (Sample calculations that compare the District's composite freeboard procedure with the use of the hydraulic depth are provided in Appendix E of the 2002 *Coyote Watershed Program Lower Silver Creek Improvement Project Final Hydraulic Report*.) Furthermore, the energy grade line shall be contained within the channel or its floodwalls.

LEVEL OF MAINTENANCE

Regular channel maintenance is important to upholding the integrity of channel design. During preliminary and final design phases, proposed maintenance protocols on the part of the District will be iteratively evaluated for their impact on design channel roughness, but within the confines of the approved Lower Silver Creek Maintenance Plan of August 2000. For instance, natural elements including grasses and emergent wetlands that are allowed to become "contaminated" with woody vegetation such as brush, willows, and even trees would be assumed to have higher roughness values in the 0.10 to 0.15 range.

CHAPTER 5
CHANNEL HYDRAULICS

Base flood elevations within Lower Silver Creek are estimated using a one-dimensional steady state flow backwater analysis via the HEC-RAS public domain program. Steady state analyses are performed. PSOMAS' Phase I construction plans dated July 15, 2004, Phase II plans dated April 6, 2004 and Phase III plans dated July 15, 2004 been used to construct the model for proposed channel geometry.

Available data include record drawings for previously constructed bridges and culverts, proposed channel design plans, field surveys of existing topography for Lower Silver Creek supplied by the Coyote Watershed Program, and supplemental surveys performed by PSOMAS. This information is supplemented by field surveys performed by Schaaf & Wheeler at every bridge or culvert crossing between McKee Road and Interstate 680.

METHODOLOGY

Flood flows can be carried within channels either as "subcritical" flow or "supercritical" flow, often referred to as "tranquil" and "rapid" flow, respectively. It is not the velocity of flow, however, that distinguishes the flow regime; rather, the flow regime is defined by how fast the water is moving relative to the velocity of the wave that results from a small disturbance in the water surface. Disturbances in subcritical flow move upstream; disturbances in supercritical flow cannot move upstream because such waves must be swept downstream. The Froude number (F_r), which is analogous to the Mach number for gas flow, is defined as the ratio of stream velocity to wave velocity:

$$F_r = \frac{v}{\sqrt{g\,y}}$$

where v = stream velocity (feet per second)
g = gravitational acceleration (feet per second squared)
y = water depth (feet)

A Froude number greater than unity signifies supercritical flow (stream velocity greater than wave velocity), while a Froude number less than one indicates subcritical flow. When the Froude number is between 0.8 and 1.2, however, the flow can be unstable, characterized by standing waves and other disturbances that may tend to propagate upstream or downstream depending upon the state of flow.

Because the Froude number depends on channel roughness, and “n” values are expected to vary within any given reach, the specific energy freeboard criterion has been kept to insure that the channel design provides protection against unexpected changes in the flow regime. Design criteria from Chapter 4 are used to establish required freeboard at the upper end of the design channel roughness range. Then normal depth starting conditions and the lower end of channel roughness are simulated to examine channel stability under mixed flow conditions; that is, with both supercritical and subcritical flow. Critical flow is assumed as the upstream boundary condition at Cunningham Avenue for the latter analysis.

Superelevation

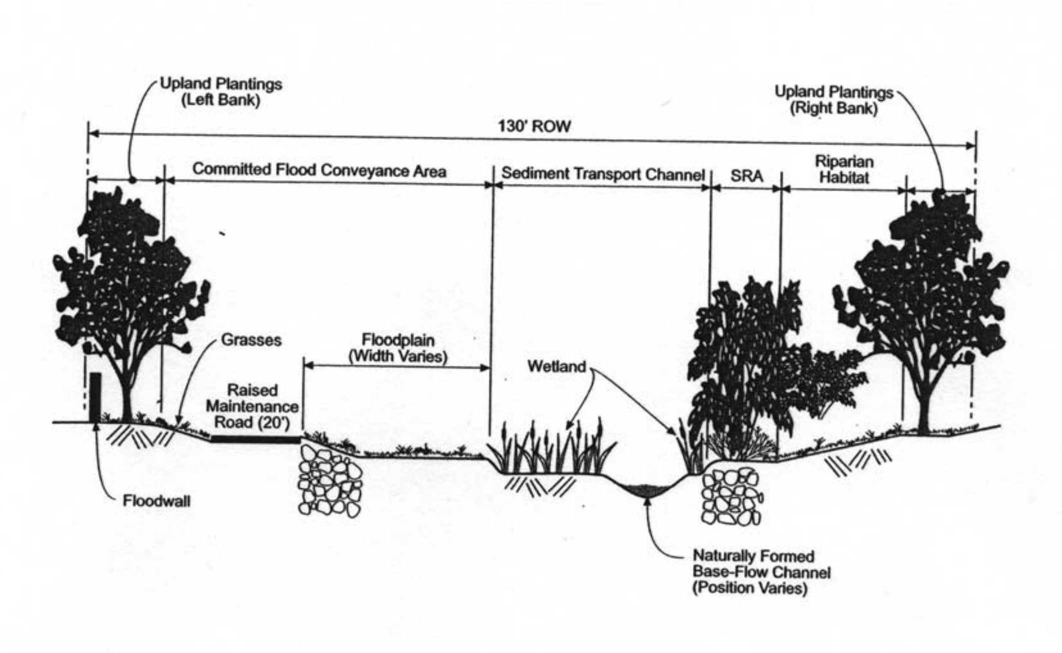
At a limited number of locations discussed later in this chapter, the proposed channel is aligned along sweeping bends. The centrifugal force caused by flow around a curve raises the water surface on the outside wall of the curve, and depresses the water surface along the inside wall. This phenomenon is referred to as superelevation. In addition, curved channels tend to create secondary helicoidal flows that may persist downstream of the curve. Superelevation is checked with both high and low Manning’s “n” values to determine the most critical case for wall freeboard. The maximum amount of superelevation above the level water surface predicted by HEC-RAS is given by the following equation (ASCE, 1995):

$$\Delta y = C\,\frac{V^2 W}{g\,r}$$

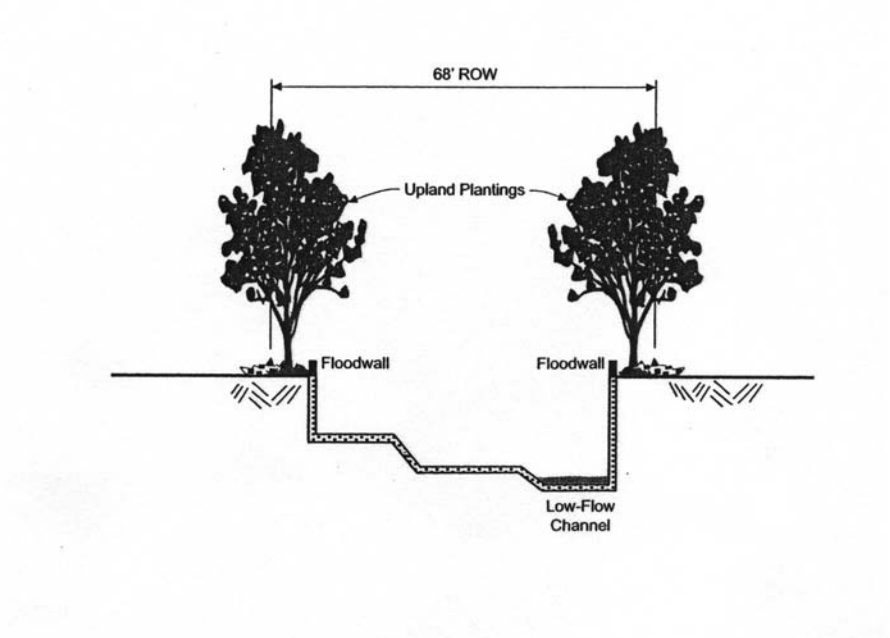
where Δy = the rise in water surface (feet)
C = a dimensionless coefficient (0.5 for subcritical flow in a simple circular curve in a rectangular channel; 1.0 for supercritical flow in the same type of curve)
V = mean channel velocity (feet per second)
W = channel width (feet)
g = gravitational acceleration (feet per second squared)
r = the radius of channel centerline curvature (feet)

PROPOSED CHANNEL IMPROVEMENTS

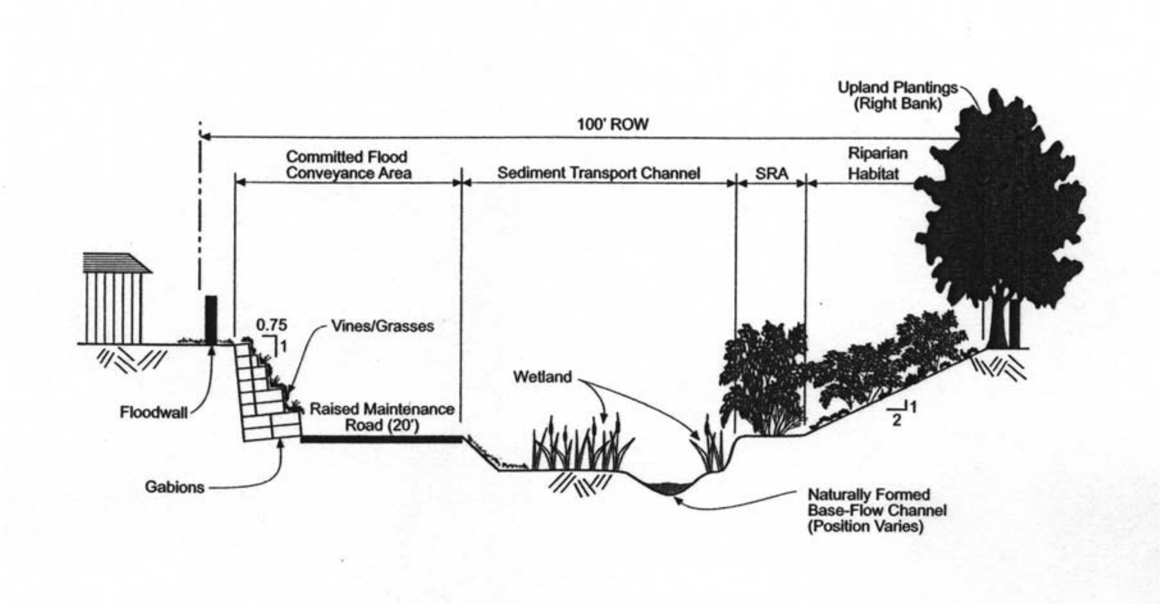
Illustrations provided below show, in a general fashion, proposed channel improvements within Reach 3. The pictures show basic channel geometries and habitats in an illustrative form only, and are not to scale. Final channel geometries and design details may vary.


Upland Plantings (Left Bank)
130' ROW
Upland Plantings (Right Bank)
Committed Flood Conveyance Area
Sediment Transport Channel
SRA
Riparian Habitat
Grasses
Floodplain (Width Varies)
Raised Maintenance Road (20')
Wetland
Floodwall
Naturally Formed Base-Flow Channel (Position Varies)

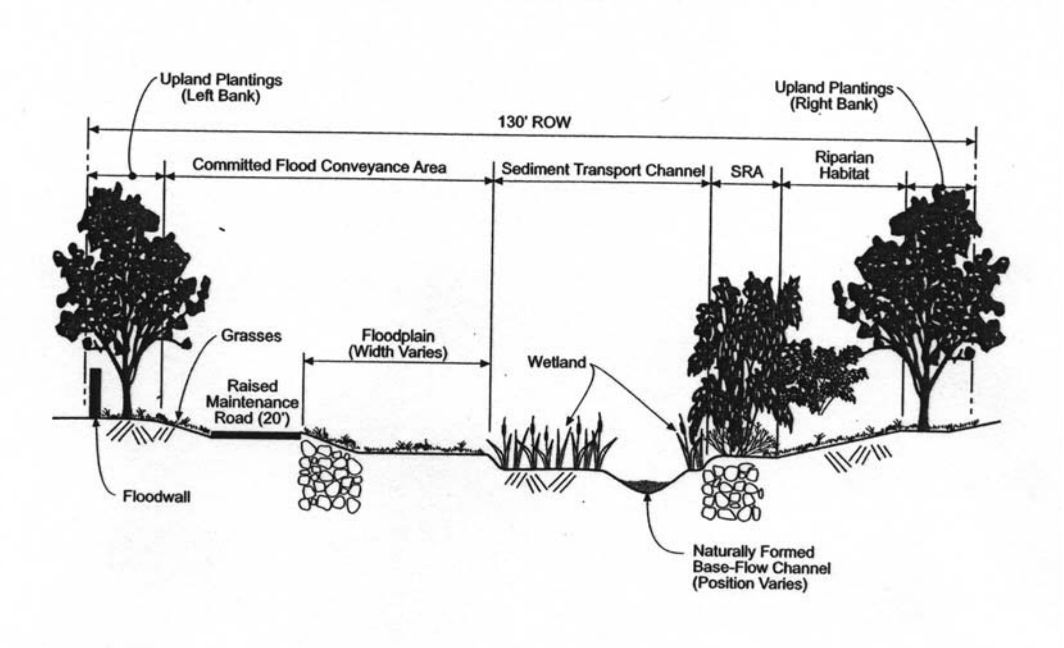
Reach 3A



Reach 3B


Upland Plantings (Right Bank)
100' ROW
Committed Flood Conveyance Area
Sediment Transport Channel
SRA
Riparian Habitat
0.75
1
Vines/Grasses
Wetland
Floodwall
Raised Maintenance Road (20')
1
2
Gabions
Naturally Formed Base-Flow Channel (Position Varies)

Reach 3C


Upland Plantings (Left Bank)
Upland Plantings (Right Bank)
130' ROW
Committed Flood Conveyance Area
Sediment Transport Channel
SRA
Riparian Habitat
Grasses
Floodplain (Width Varies)
Wetland
Raised Maintenance Road (20')
Floodwall
Naturally Formed Base-Flow Channel (Position Varies)

Reaches 3D and 3E

BRIDGE REPLACEMENT

As stated previously, the 1983 NRCS update plans appear to be based on normal depth calculations with no backwater effects due to bridges, or other transitions. Under that assumption, the one-percent water surface is carried at or near the natural banks of Lower Silver Creek, as is the case with the Project Improvement Plans. Floodwalls and levees would primarily be constructed to meet District freeboard criteria, and would be on the order of no more than about three feet above natural ground for the most part. As discussed in this chapter, however, bridges and other structures can have a significant impact on water surface elevations, to the point where bridge and culvert improvements are necessary to avoid excessively high floodwalls.

Table 5-1 presents a step-wise backwater analysis that looks at the effects of rehabilitating individual bridges in Reach 3 beginning downstream at Alum Rock Avenue. Bridges or culverts are recommended for improvement or replacement if the one-percent energy loss through them is sufficient to raise floodwall heights above four feet as measured from nearest adjacent grade, or if there are other compelling aesthetic or economic concerns as explained herein. Bridges off limits to replacement for economic or other reasons include McKee / King Road and Interstate 680.

Table 5-1: Reach 3 Stepwise Bridge Replacement Matrix

Bridge Location	Existing Bridge Structures		Replace?	With New Bridge Structures	
	1% WSEL	U/S Floodwall Height		1% WSEL	U/S Floodwall Height
Alum Rock Avenue	107.52	16.3’	**YES**	92.65	N/A
Sunset Avenue	99.39	6.0’	**YES**	95.45	1.7’
San Antonio Street	99.84	1.2’	NO	99.11	0.5’

HYDRAULIC DESIGN EVALUATION

Design one-percent water surface profiles are included in this Chapter. Appendix C contains detailed information about design water surface elevations, channel velocities, freeboard requirements, and Froude Number (channel stability) for both extremes of channel roughness. Within the following paragraphs, design freeboard and hydraulic stability are addressed. Channel cross sections referenced in this report are oriented looking upstream. The Program’s hydraulic model has been revised to incorporate any changes made to proposed channel geometries as described by the Reach 1 and 2 Conform Set of May 3, 2002 and the aforementioned Reach 3 Phase I, II, and III construction plans. Water surface elevations are provided at the end of this chapter.

Backwater from the constriction formed by the McKee Road culvert influences the design water surface profile upstream to Alum Rock Avenue. Although a containment berm will be built between the creek and Plata Arroyo Park, the combination of high backwater from McKee and relatively low adjacent grade in the park means FEMA freeboard governs the design of floodwalls through this reach. The planned berm is not high enough to meet the criterion. By agreement with the City of San Jose, regulatory floodwater will be mapped in the park, although nearly three feet of freeboard are provided. The 100-year Special Flood Hazard Area (SFHA) will include the basketball courts and most of the park itself as shown in Figure 5-1.

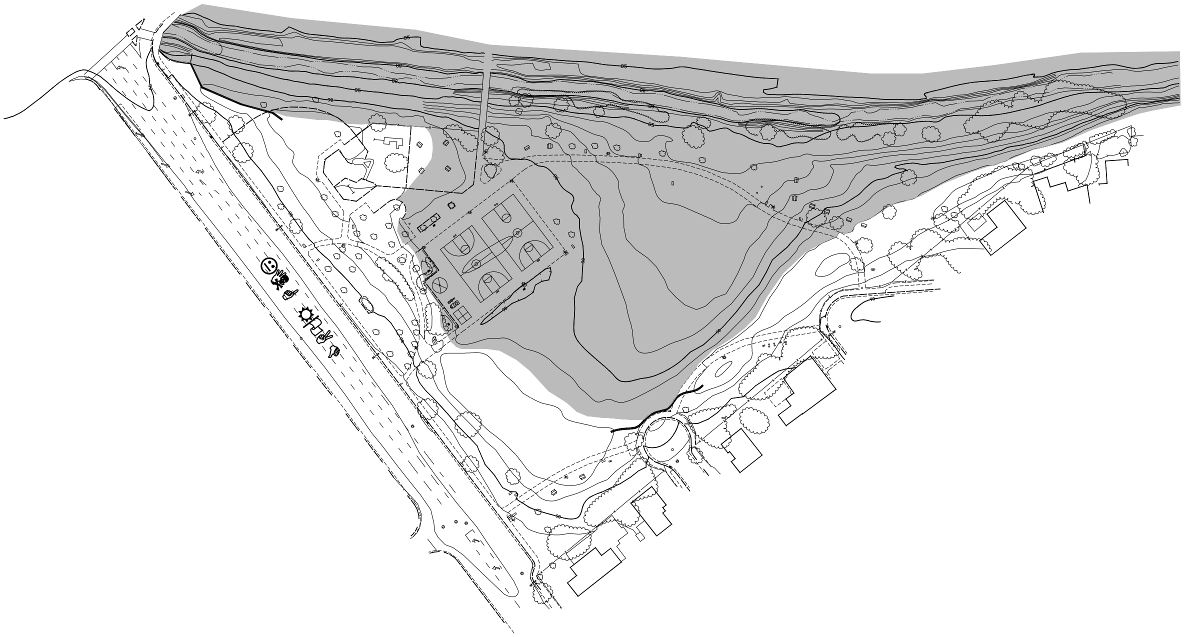


Figure 5-1: Plata Arroyo Special Flood Hazard Area

Proposed bridge replacements at Alum Rock Avenue and Sunset Avenue enable the design water surface elevation to be carried well below natural grade with adequate freeboard, even under potentially supercritical conditions (low "n") in the concrete lined portions of this reach. Maximum water surface superelevation under potential supercritical flow could reach almost one foot, but this is well below natural grade. Under subcritical flow conditions, the superelevation is limited to less than 0.2 foot.

At Alum Rock Avenue the constriction in width imposed by the existing bridge causes the problems presented in Table 5-1. These problems can be solved by replacing this bridge with a longer clear-span structure across the proposed U-frame channel section carried upstream from Reach 3B. This replacement bridge structure is not part of the improvements shown on the PSOMAS plans. It must be emphasized that unless the Alum Rock structure is replaced, the upstream channel cannot function as designed, and will not contain the one-percent flood with the proposed system of floodwalls.

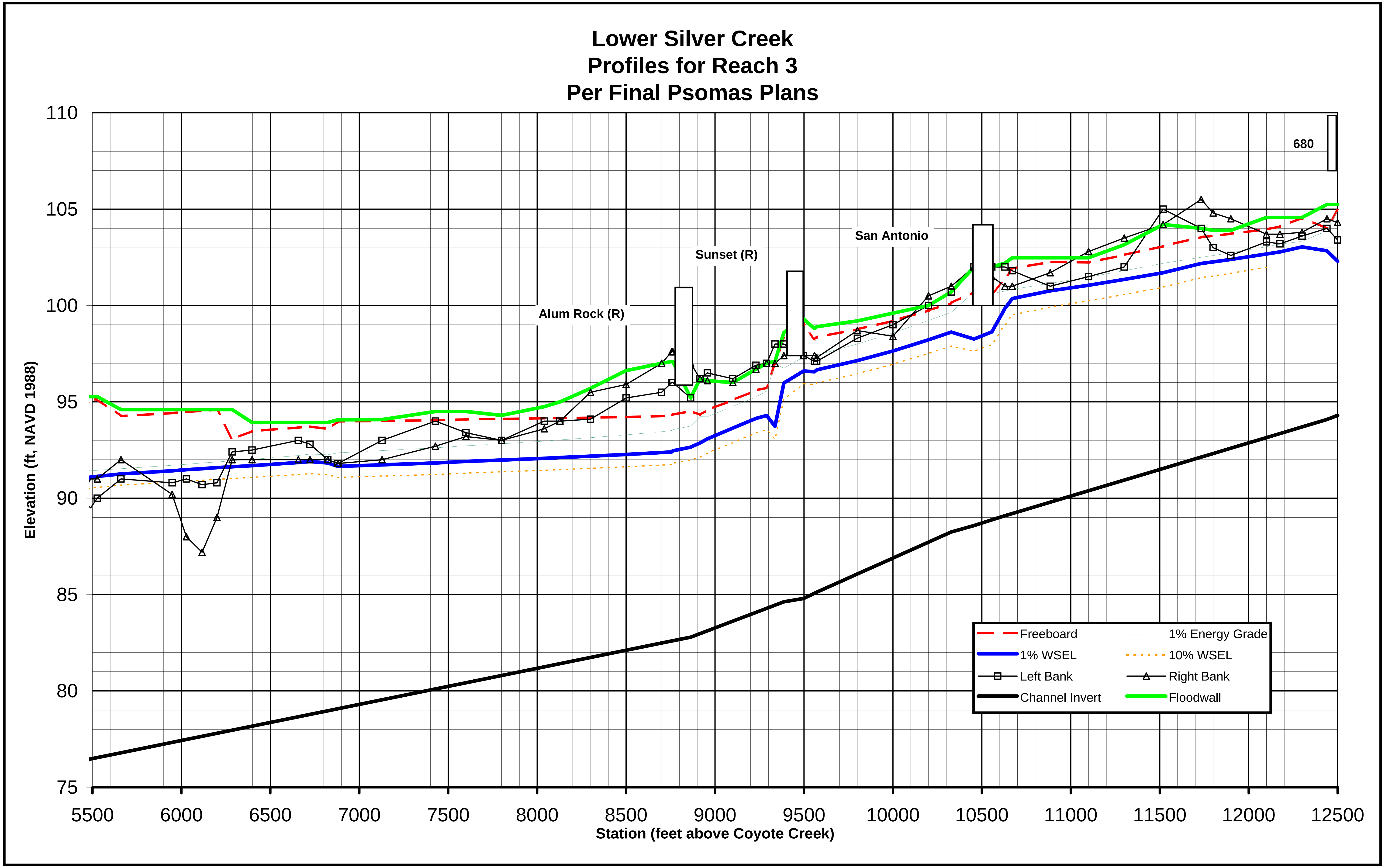
Installing two additional 10' x 12'-6" box culverts will rectify a similar but less extreme hydraulic constriction at Sunset Avenue. The new culvert invert will be depressed to allow for a naturally forming low-flow channel to cut itself through this reach.

At San Antonio Street, the existing bridge does not pose a particular hydraulic problem. To simplify the transitions to the upstream and downstream channel sections, and modify the channel invert as desired, the existing "floating" channel lining will be removed and replaced with nearly vertical (0.5H:1V) walls against the abutments. The floating lining is not structurally tied to the bridge abutments or superstructure, and can be removed without compromising the bridge's structural integrity.

Between San Antonio Street and Interstate 680, freeboard walls are needed primarily along the left bank to protect the overbank where natural ground is slightly low. Floodwater will be allowed to leave the south right-of-way and encroach slightly into Mayfair Park, where the water is contained by higher ground. If vegetation is not established prior to a large runoff event, or is removed during such an event, there is the potential for a hydraulic jump to form between Stations 123+50 and 124+50, where the unstable energy grade line would not necessarily be contained by the proposed freeboard. This is considered to be an unlikely scenario, but it does emphasize the need to provide temporary erosion protection until vegetation is established.

INTERIOR DRAINAGE ADJACENT TO FLOODWALLS

The construction of floodwalls along the creek could trap local drainage water against the wall system, and commensurately increase the depth of local flooding when natural overland release to the creek is eliminated. In general, however, Lower Silver Creek is a “perched” channel whereby drainage tends to run away from the creek rather than toward it. For the most part, the construction of floodwalls will not adversely impact local drainage patterns, other than perhaps the back half of lots directly adjacent to the creek. Drainage systems should be provided or modified as needed.


Lower Silver Creek
Profiles for Reach 3
Per Final Psomas Plans
Elevation (ft, NAVD 1988)
110
105
100
95
90
85
80
75
5500
6000
6500
7000
7500
8000
8500
9000
9500
10000
10500
11000
11500
12000
12500
Station (feet above Coyote Creek)
Alum Rock (R)
Sunset (R)
San Antonio
680
Freeboard
1% Energy Grade
1% WSEL
10% WSEL
Left Bank
Right Bank
Channel Invert
Floodwall

CHAPTER 6
SEDIMENT MANAGEMENT

The management of scour and sediment deposition within Lower Silver Creek may have a great impact on the future success of proposed flood protection and geomorphic improvements. This chapter addresses low-flow and extreme event sedimentation in a preliminary manner.

BASIC SEDIMENT TRANSPORT CONCEPTS

Sediment originates from the upland areas of the tributary catchments, and is transported down the natural and concrete-lined channels, with a portion of that transported sediment reaching the outfall at Coyote Creek. Sediment transport between Lake Cunningham and Coyote Creek can affect the potential for deposition or scour within Reach 3. If these sediment processes are not properly managed over time, the channel will not perform as designed and could exacerbate the potential for urban flooding.

Sediment Transport Capacity

Sediment transport capacity is defined as the ability of flowing water to move sediment downstream. A variety of variables can be used to quantify the magnitude of sediment transport capacity, but the product of unit weight of water (γ), flow depth (y), flow velocity (v) and energy slope (s) has been found to be a good predictor. This product is known as the stream power per unit area, that is:

$$\textit{Stream Power} = \gamma \; y \; v \; s$$

The impact of potential changes to a channel design on sediment transport capacity can be assessed with this equation. For example, if water is diverted out of a channel, the product of velocity, flow depth and energy slope of the flowing water remaining in the channel is likely to diminish. This implies that the sediment transport capacity of the water remaining in the channel may decrease.

Sediment Availability

Sediment availability determines, concurrently with the transport capacity, how much sediment water flowing in a stream will carry. If, for example, a stream can carry 10 pounds of sediment per second, but upstream erosion from the river bed and banks, and other sediment input make only 5 pounds of sediment per second available for transport, then the sediment carried by the stream cannot exceed 5 pounds of sediment per second. Conversely, if 10 pounds of sediment per second is available to be transported by a stream, but its sediment transport capacity is only 5 pounds of sediment per second, then only 5 pounds of sediment per second will be transported. The remainder will be deposited.

Sediment Load

Sediment load consists of wash, suspended and bed loads. Wash load is made up of very fine, colloidal particles such as clay, that often remain in suspension even when the sediment transport capacity of the water reduces significantly. Suspended load consists of fine sediment particles, and can settle onto the riverbed or flooded overbank areas if the sediment transport capacity of the water reduces enough. Most of the sediments found in Lower Silver Creek fall into this category. Bed load is coarser material that moves along the riverbed as flowing water drags it along. It ceases to move as the sediment transport capacity of the water diminishes.

If flow in a channel is large enough to overtop its banks, the bed load usually remains in the main channel, while the suspended and wash load are contained in the water column over the main channel and in the water column over the flooded overbank area. The sediment transport capacity in the main channel is often large enough to maintain suspension of the suspended load within this water column, but it can reduce enough in the flooded overbank area to deposit the suspended sediment (and sometimes even the wash load).

Maintenance Flow

A typical natural cross section of a stream consists of a main channel and an overbank (also known as a floodplain). Research and field observations over many years suggest that the water discharge capacity of the main channel (i.e. the volume of water that it can discharge per second when it flows full to the edge of its bank) is equivalent to approximately the two-year recurrence interval flow. When the discharge in the stream exceeds this flow magnitude, it overtops its banks with water flowing onto the floodplain.

LOW-FLOW REGIMES

Annual sediment management is primarily concerned with sediment transport behavior for low-flow events. One of the Program's goals is to provide for naturally occurring sediment transport within significant reaches of the unlined channel. This portion of the report addresses sedimentation during low-flow events and examines the potential for annual sediment loading from influent tributaries.

Sediment Transport Channel

An unlined sediment transport channel has been proposed as a mechanism for providing natural deposition and scour in Lower Silver Creek. As a natural phenomenon, the quantitative geomorphologic behavior of this channel is unpredictable, but since its size and slope will not be significantly different than the existing channel section, past geomorphology is likely to be a good predictor of future conditions, assuming that the average climate remains about the same.

Photographs from Chapter 2 provide one predictor of sediment transport channel behavior. For the most part, the existing low-flow channel is straight with some slight meandering in certain reaches. Sediment deposits at the fringes of the open water support emergent wetland vegetation. Significant accumulations of sediment and more extensive vegetation are seen just upstream of the McKee Road Bridge in Reach 3, Interstate 680 in Reach 4, and Cunningham Avenue at the upstream limit of Reach 6.

Table 6-1 provides an assessment of minimum discharges required to initiate bed particle movement within the sediment transport channel in Reach 3. (For a point of reference, the design depth of the transport channel will vary from 2.5 to 3.0 feet depending upon the reach.) Since the minimum estimated two-year discharge is 600 cfs, there should be some transport of sediment in all reaches at least every other year. At District direction, a roughness coefficient of 0.04 is assumed for this analysis. Based on grain size distributions for sediment near Lake Cunningham, the largest particle size that needs to be transported downstream is approximately 2mm, which represents large sand. The critical velocity for incipient sediment motion is calculated as:

$$V_c = K_u \; y^{1/6} \; D^{1/3}$$

where V_c = critical velocity to transport sediment of size D and smaller
y = average depth of flow
D = median particle size (2 mm)
K_u = 11.17 (dimensionless)

Table 6-1: Threshold of Discharge for Sediment Transport

Reach	Transport Channel Width	Threshold Discharge for Transport	Depth of Flow at Incipient Motion
3A	30 feet	250 cfs	2.5 feet
3D	26 feet	60 cfs	1.0 foot
3E,F	26 feet	80 cfs	1.3 feet

Stream Slope Stability

Without detailed knowledge of the sediment supply from the Lake Cunningham area or tributary creeks, a preliminary slope stability analysis has been made using a tractive force analysis to estimate the equilibrium slope where bed material movement ceases:

$$S_{eq} = \left[K_s \, D_c \left(\frac{\gamma_s - \gamma}{\gamma} \right) \right]^{(10/7)} \left(\frac{K_u}{qn} \right)^{(6/7)}$$

where S_{eq} = Channel slope at which particles D_c will no longer move
q = Discharge per unit width
K_s = Shield’s Parameter
K_u = 1.486
n = Manning roughness coefficient = 0.020 as a worst case
D_c = Critical bed material size = D_{90}
γ = Unit weight of water = 62.4 pounds per cubic foot
γ_s = Unit weight of sediment = 165 pounds per cubic foot (specific gravity = 2.65)

The critical size of sediment used in this equation is D_{90} because the streambed will coarsen (armor itself) as degradation occurs. Sediment sizes are based on gradation curves provided by Parikh Consultants, Kleinfelder, and Geotechnical Consultants for soil borings taken near the depth of the finished channel invert. Long-term slope stability is predicated upon the “dominant discharge,” which is typically considered to be the two-year flow.

The Shield’s Parameter is a function of bed shear and sediment size:

$$U_{*,c} = \left(\frac{\gamma \text{ d S}}{\rho} \right)^{1/2}$$

where $U_{*,c}$ = Shear velocity (feet per second)
γ = Specific weight of water = 62.4 pounds per cubic foot
d = Depth of flow (feet)
S = Energy gradient (foot per foot)
ρ = Density of water (1.94 slugs per cubic foot)

The boundary Reynolds Number is:

$$R_* = \frac{U_{*,c} \, d_c}{\upsilon}$$

where $U_{*,c}$ = Shear velocity (feet per second)
d_c = critical bed material size (feet)
ν = kinematic viscosity of water = 0.00001 feet squared per second

Shield's diagram published by ASCE (Sedimentation Engineering, 1975) is used to obtain K_s. The specific gravity of streambed material is assumed to be 2.65 in all calculations. Appendix C provides a table listing equilibrium slopes calculated within the reach, together with a maximum expected depth of upstream degradation, and recommended spacing of channel stability measures that would limit maximum long-term depth degradation to three feet, which is the desired depth of the naturally forming low flow channel. The analysis provided in Appendix C is based on hard maintenance floors at the following bridges or channel sections within Reach 3:

McKee Road
Reach 3B U-frame
Interstate 680
Sunset Avenue

Calculations show that maximum predicted long-term degradation could be up to 7 feet without additional grade stabilization measures. Although it is not analytically possible to include the effects of the cohesive soils on-site, additional five-foot deep cutoff walls installed at the following locations within Reach 3 are proposed to minimize the potential for long-term invert degradation:

Station 54+75
Station 68+23
Station 89+16
Station 93+38
Station 96+04
Station 103+29
Station 106+30
Station 124+47

SOURCES OF ADDITIONAL SEDIMENT

If the channels that deliver runoff from Tully Road to Cunningham Avenue are utilized as sediment retention facilities as planned, then the inflow of bed-load sediment to Lower Silver Creek should be limited to its downstream tributaries. Based on previous statistical analyses performed by Schaaf & Wheeler for the District's Norwood Creek and Flint Creek debris basins, the average annual debris and sediment loading factor is about 650 cubic yards per tributary square mile per year. This statistic is for rural areas, and if the factor is applied to the rural tributaries of South Babb, North Babb, and Miguelita Creeks, these annual debris loadings might be expected:

South Babb Creek	3.4 mi^2	2,200 CY/year
North Babb Creek	1.1 mi^2	800 CY/year
Miguelita Creek	1.8 mi^2	1,200 CY/year

Predicting the average amount of sediment that will actually reach Lower Silver Creek is difficult, because sediment transport could be limited by the “creek” conveyance facilities through urban areas. (South Babb Creek runs in a concrete box culvert, while North Babb and Miguelita Creeks flow through concrete pipes.)

SEDIMENT TRANSPORT DURING EXTREME EVENTS

The movement of sediment during extreme runoff events has far more damage potential than the previously discussed low-flow regime transport concepts. If sediment transport is severe enough, there is the potential for catastrophic channel damage and flooding.

To assess the potential for in-channel scour and deposition, one can examine a plot of stream power against river station (Figure 6-1 at the end of this chapter). Neglecting the effects of additional sediments from Lake Cunningham and Lower Silver Creek’s tributaries, this plot addresses the potential for in-channel scour and deposition during extreme runoff conditions such as the one-percent event. Increasing stream power in the downstream direction indicates a potential for **scour**, where the stream flow entrains additional sediments to balance the transport capacity, such as between San Antonio Street and Sunset Avenue in Reach 3C.

Decreasing stream power in the downstream direction indicates that the channel reach cannot carry as much sediment as upstream reaches have delivered. When sediment availability exceeds the transport capacity, the excess sediment will be **deposited**, in areas such as these:

Sunset Avenue Culvert
McKee Road to Alum Rock Avenue (backwater from McKee Road Culvert)
McKee Road Culvert

Detailed watershed assessments and sediment transport modeling would be necessary to estimate long-term sediment conditions, predict actual scour depths, or analyze sediment accumulations during a design event. These types of analyses are beyond the scope of this report.

Tractive Force Analysis

Flowing water in a channel develops forces, known as tractive forces or shear forces, acting in the direction of flow on the channel bed and sides. The average value of the tractive force per unit wetted area, or unit tractive force, is calculated as:

$$\tau_o = \gamma R \; S$$

where τ_0 = Unit tractive force (pounds per square foot)

γ = Specific weight of water (62.4 pounds per cubic foot)

R = Hydraulic radius (feet)

S = Energy gradient (foot per foot)

The unit tractive force can be calculated for the flow condition of interest, and compared to the permissible unit tractive force for the type of material through which the channel is excavated. According to Chow, in a trapezoidal channel 97 percent of the unit tractive force is distributed to the bed and 75 percent of the force is distributed to the banks.

Reach 3 of Lower Silver Creek will be excavated through cohesive material such as clay, silty clay, and sandy clay. Therefore values of permissible unit tractive forces for cohesive material as converted from USBR data on permissible velocities (Chow, 1959) are compared to actual unit tractive forces. Permissible tractive force in a cohesive material is a function of the voids ratio and type of soil, which are obtained from soil testing results along the channel. Appendix C provides the comparison.

Tractive force analyses in Appendix C show that if vegetation does not become well established to provide erosion protection, both the channel bed and banks will be subject to erosive velocities and will scour in the design flood event. For unlined reaches of the channel, well-established vegetation is critical to increase channel roughness and reduce the shear force. However, even with increased channel roughness, the design will rely upon vegetation to provide erosion protection, since the estimated tractive force on the banks is still greater than permissible in several reaches.

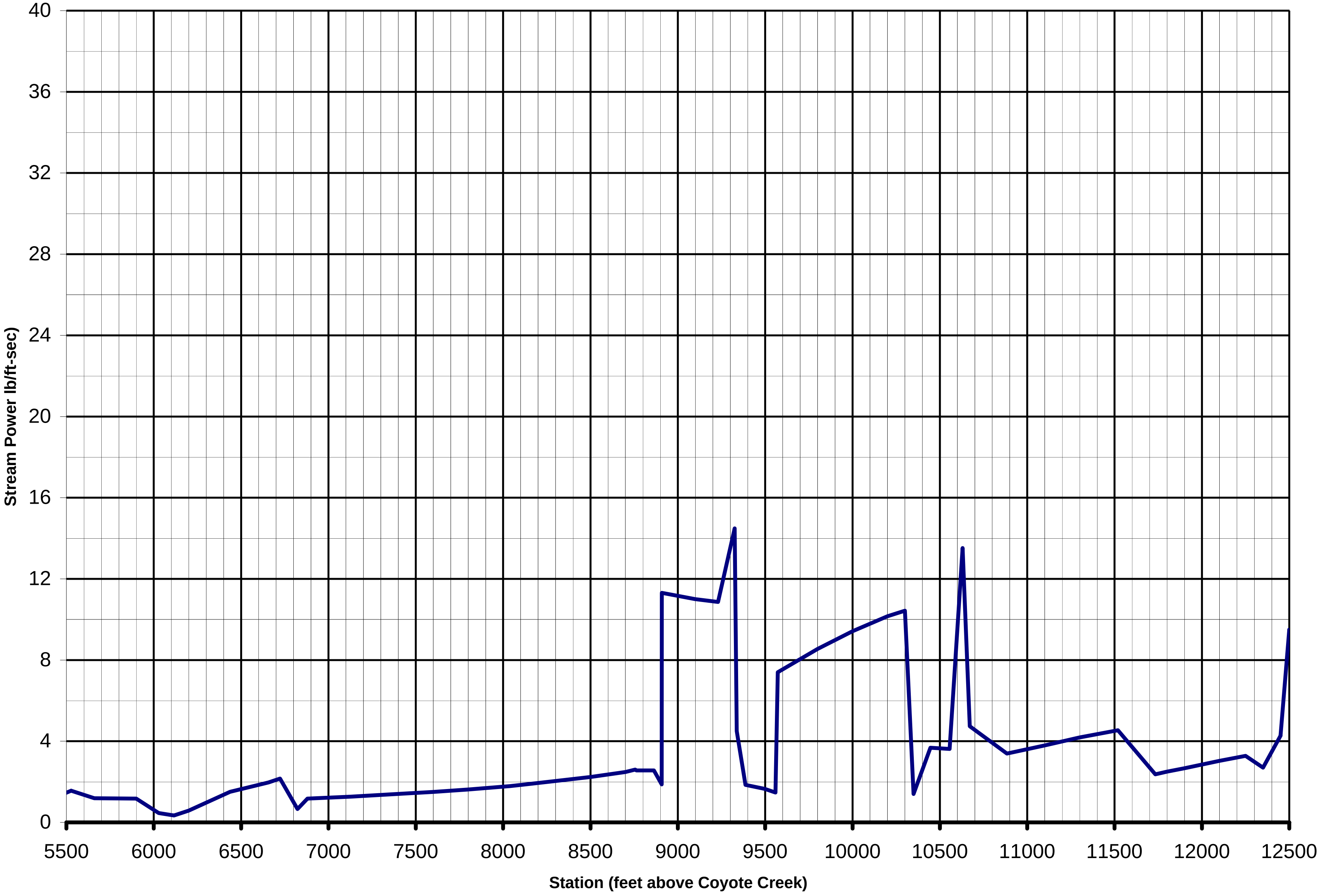
Bridge Scour

Bridge scour analyses are also beyond the scope of this report, but an order-of-magnitude estimate at the San Antonio Street Bridge indicates that 3 feet of local pier scour could occur during the design discharge event without the proposed concrete invert protection.

MAINTENANCE GUIDELINES

If the sediment transport channel is allowed to completely fill with sediment, the one-percent discharge is passed while leaving no less than about one-half of the design freeboard. The sediment transport channel should be inspected annually. When the average depth of sediment is to within approximately one foot of the level of the maintenance road, the sediment should be removed to original grade. Any sediment that remains on the maintenance road will begin to compromise freeboard and eventually one-percent flood protection.

Figure 6-1: Lower Silver Creek
Sediment Transport Capacity for Reach 3
Program Improvements w/ Bridge Replacement



APPENDIX A
LIST OF TECHNICAL TERMS AND ACRONYMS

Acre-Foot	A quantity of water that would cover 1 acre to a depth of 1-foot, equal to about 325,000 gallons.
Aggradation	The geologic process by which streambeds and floodplains are raised in elevation by the deposition of material eroded and transported from other areas. It is the opposite of *degradation*.
Alluvial	Deposition by the action of running or receding water.
Antecedent	An event that precedes another event.
Backwater	Water held back by a downstream control such as a bridge, constricted channel, or tide.
Base Flood	See *one-percent flood*.
Bed Load	Sediment bouncing or rolling along the bottom of a stream. See also *suspended load*.
Dominant Discharge	The dominant *discharge* that causes natural channels to form, usually equivalent to the 50-percent (2-year) discharge. Also known as bank-full discharge.
City	City of San Jose, California.
Confluence	The junction of two streams.
Conveyance	The ability of a stream or channel to pass a certain rate of flow.
Critical Flow	Water is moving just as fast, relative to the channel banks, as the wave resulting from a small disturbance moves relative to the water. Standing waves are characteristic of critical flow conditions. Critical flow conditions can be unstable. See also *subcritical flow* and *supercritical flow*.
Cross Section	A vertical section of a stream channel or structure that provides a side view of the structure; a transect taken at right angles to flow direction.
Cfs	A rate of flow equivalent to 1 cubic foot, or about 7 2 gallons, Passing a point during 1 second (450 gallons/minute).
Degradation	The geologic process by which stream and river beds lower in

	elevation. It is the opposite of *aggradation*.
Design Flow	The magnitude of streamflow (see *discharge*) that is used in design of channel modifications and structures across channels.
Discharge	The volume of water passing through a channel during a given period of time. Usually measured in cubic feet per second.
District	Santa Clara Valley Water District.
El Niño	A disruption of the ocean-atmosphere system in the Tropical Pacific having important consequences for weather and climate around the globe. An El Niño tends to increase rainfall across the southern tier of the United States. The 1997-1998 El Niño was very strong, and caused destructive flooding throughout Northern California.
FEMA	Federal Emergency Management Agency.
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
Floodplain	An area of land inundated by *floodwaters*. Floodplains may consist of standing or moving water.
Floodwaters	Those flows of water that cannot be contained within the natural stream channel.
Freeboard	Vertical distance between the top of an embankment adjoining a channel and the water level in the channel. It is a factor of safety designed into a project.
Gravel	Sediment particles larger than sand and ranging from 0.25 to 3 inches in diameter.
Hydraulic Jump	The transition of flow from the *supercritical* to the *subcritical* condition; the change characterized by turbulence and energy loss.
Hydrograph	A plot of *discharge* (flow) against time.
Inlet Control	Flow through a bridge, culvert, or pipe where the upstream water surface elevation is determined only from the geometric characteristics of the entrance to the structure.
Low Flow Channel	A subchannel of the main stream channel that is designed to

	concentrate low flows for biological or aesthetic reasons.
NAVD	Adjusted vertical datum of 1988. Generally 2.75 to 2.9 feet higher than NGVD in project area.
NGVD	The *mean sea level* in 1929. National Geodetic Vertical Datum.
NFIP	National Flood Insurance Program.
NPDES	National Pollutant Discharge Elimination System.
100-Year Flood	The *one-percent flood*.
1% Flood	A flood magnitude that has a one percent chance of being equaled or exceeded in any one year.
Ordinary High Water	The area of a watercourse subject to Section 404 of the Federal Clean Water Act of 1972. The area affected is determined by the elevation of the 2.3-year flood event (ordinary high water flow) which is field checked by biologists using physical characteristics.
Outlet Control	Flow through a bridge, culvert, or pipe where the upstream water surface elevation is determined from the downstream water elevation and/or energy losses through the structure and its entrance.
Overbank	In a river or creek, the area between the main channel and the limits of the *floodplain*.
Overflow	*Floodwater* that leaves a channel over its bank(s).
Pressure Flow	Flow under pressure through a tube, such as formed by a pipe, bridge deck, or culvert. Opposite of open channel flow where there is a free surface.
Reach	A subdivision of the creek for convenience of study and reference.
Riparian	Vegetation and wildlife living within, and immediately adjacent to a river, stream or lake. In this report, riparian means the creek environment.
Roughness	Represents the frictional resistance of a surface to the flow of water. Used in hydraulic computations. Also, Manning's "n".
Sacked Concrete	Burlap bags filled with concrete and placed on a stream bank to

Slope Protection (SCSP)	protect the bank against erosion.
SCVWD	Santa Clara Valley Water District.
Sequent Depth	Corresponding water depths upstream and downstream of a *hydraulic jump*, also known as conjugate depth.
Soffit	The underside of a bridge deck, or the top of a box culvert. If the water surface elevation is at or above the soffit, *pressure* flow or *inlet* control may occur.
Subcritical Flow	Flow conditions in which a wave from a disturbance moves upstream. Also known as Tranquil Flow. See also *backwater*.
Supercritical Flow	Flow conditions in which a wave from a disturbance moves downstream. Also known as Rapid Flow. Supercritical flow conditions can lead to high velocities and shock wave formation at the location of channel geometry changes.
Suspended Load	The part of the total sediment load that is carried for a considerable period of time at the velocity of the flow, free from contact with the streambed. See also *bed load*.
Wash Load	The part of the *suspended load* comprised of very fine, colloidal particles such as clay.
Watershed	The geographical region or area drained by a stream. Also referred to as a drainage basin or tributary.
Wetlands	As used herein, areas that under normal circumstances have hydrophytic vegetation, hydric soils, and wetland hydrology.

APPENDIX B
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APPENDIX C
HYDRAULIC BACKUP

Composite Roughness Calculations..C-1
Hydraulic Summary for Proposed Improvements C-5
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Coyote Watershed Program
Lower Silver Creek Reaches 1 thru 6

Composite Roughness Calculations Using Chow Equation (6-19)

Reach 3A

Station 54+28 to Station 66+57

Channel Element	b	Left SS	Right SS	depth	n
Left Bank		2			0.04
Maintenance Road	20				0.03
Grassed Floodplain	3	1		2	0.04
Wetland	30	4	2	3	0.05
Riparian Bench	5				0.15
Right Bank			2		0.15

Total Discharge	**4,340**	cfs
Maximum Depth	**14.5**	feet

Element	n_i	A_i	P_i	R_i	$P_iR_i^{5/3}/n_i$	Q_i	V_i	$V_i^3A_i$
Left Bank	0.040	90.25	21.24	4.25	5,919	211	2.34	1,160
Maintenance Road	0.030	190.00	20.00	9.50	28,408	1,015	5.34	28,951
Grassed Floodplain	0.040	55.50	5.83	9.52	6,233	223	4.01	3,584
Wetland	0.050	669.00	49.08	13.63	76,352	2,727	4.08	45,335
Riparian Bench	0.150	57.50	5.00	11.50	1,953	70	1.21	103
Right Bank	0.150	132.25	25.71	5.14	2,627	94	0.71	47
Summation		1,194.50	126.86	9.42	121,492	4,340		79,180

Average Velocity	3.63	fps
Composite n	0.044	
a	1.38	

n Used	0.045
a Used	1.40

Coyote Watershed Program
Lower Silver Creek Reaches 1 thru 6

Composite Roughness Calculations Using Chow Equation (6-19)

Reach 3C&D

Station 89+08 to Station 103+28

Channel Element	b	Left SS	Right SS	depth	n
Left Bank		1.67			0.045
Maintenance Road	20				0.03
Grassed Floodplain	1E-07	0		0	0.04
Wetland	26	2	2	3	0.05
Riparian Bench	5				0.15
Right Bank			2		0.15

Total Discharge	**4,210**	cfs
Maximum Depth	**11**	feet

Element	n_i	A_i	P_i	R_i	$P_iR_i^{5/3}/n_i$	Q_i	V_i	$V_i^3A_i$
Left Bank	0.045	53.44	15.57	3.43	2,702	179	3.35	2,003
Maintenance Road	0.030	160.00	20.00	8.00	21,333	1,412	8.83	110,014
Grassed Floodplain	0.040	0.00	0.00	8.00	0	0	6.62	0
Wetland	0.050	400.00	39.42	10.15	37,498	2,482	6.21	95,593
Riparian Bench	0.150	40.00	5.00	8.00	1,067	71	1.77	220
Right Bank	0.150	64.00	17.89	3.58	998	66	1.03	70
Summation		717.44	97.88	7.33	63,598	4,210		207,900

Average Velocity	5.87	fps
Composite n	0.043	
a	1.43	
n Used	0.045	
a Used	1.45	

Coyote Watershed Program
Lower Silver Creek Reaches 1 thru 6

Composite Roughness Calculations Using Chow Equation (6-19)

Reach 3E

Station 108+84 to Station 115+19

Channel Element	b	Left SS	Right SS	depth	n
Left Bank		2			0.04
Maintenance Road	20				0.03
Grassed Floodplain	22	2		2	0.04
Wetland	26	4	2	3	0.05
Riparian Bench	5				0.15
Right Bank			2		0.15

Total Discharge	**4,210**	cfs
Maximum Depth	**10.5**	feet

Element	n_i	A_i	P_i	R_i	$P_iR_i^{5/3}/n_i$	Q_i	V_i	$V_i^3A_i$
Left Bank	0.040	30.25	12.30	2.46	1,378	81	2.67	575
Maintenance Road	0.030	110.00	20.00	5.50	11,425	669	6.08	24,778
Grassed Floodplain	0.040	191.00	26.47	7.22	17,829	1,044	5.47	31,235
Wetland	0.050	435.00	45.08	9.65	39,434	2,310	5.31	65,154
Riparian Bench	0.150	37.50	5.00	7.50	958	56	1.50	126
Right Bank	0.150	56.25	16.77	3.35	840	49	0.88	38
Summation		860.00	125.62	6.85	71,864	4,210		121,906

Average Velocity	4.90	fps
Composite n	0.043	
a	1.21	

n Used	0.045
a Used	1.20

Coyote Watershed Program
Lower Silver Creek Reaches 1 thru 6

Composite Roughness Calculations Using Chow Equation (6-19)

Reach 3F

Station 117+33 to Station 124+66

Channel Element	b	Left SS	Right SS	depth	n
Left Bank		2			0.04
Maintenance Road	20				0.03
Grassed Floodplain	51	2		2	0.04
Wetland	26	4	2	3	0.05
Riparian Bench	5				0.15
Right Bank			2		0.15

Total Discharge	**4,210**	cfs
Maximum Depth	**10.0**	feet

Element	n_i	A_i	P_i	R_i	$P_iR_i^{5/3}/n_i$	Q_i	V_i	$V_i^3A_i$
Left Bank	0.040	25.00	11.18	2.24	1,069	54	2.17	255
Maintenance Road	0.030	100.00	20.00	5.00	9,747	495	4.95	12,105
Grassed Floodplain	0.040	381.00	55.47	6.87	34,416	1,747	4.58	36,713
Wetland	0.050	413.00	45.08	9.16	36,167	1,836	4.44	36,257
Riparian Bench	0.150	35.00	5.00	7.00	854	43	1.24	66
Right Bank	0.150	49.00	15.65	3.13	699	35	0.72	19
Summation		1,003.00	152.38	6.58	82,951	4,210		85,416

Average Velocity	4.20	fps
Composite n	0.042	
a	1.15	

n Used	0.045
a Used	1.20

LOWER SILVER CREEK REACH 3

HYDRAULIC SUMMARY FOR PROPOSED CHANNEL IMPROVEMENTS

	Channel Parameters				Design Parameters						Program Freeboard Requirements				
Location	River Station	Channel Invert	LOB Elev[1]	ROB Elev[1]	10% WSEL	1% WSEL	Chan Velocity	a	E.G. Elev	Froude Number	Hydraulic Depth	0.2* D	Freeboard Line	Design Wall or Lowest Bank Elevation	Surplus Freeboard	Maximum Wall or Berm Height
		(NAVD)	(NAVD)	(NAVD)	(NAVD)	(NAVD)	(fps)		(NAVD)		(ft)	(ft)	(NAVD)	(NAVD)	(feet)	(feet)
McKee	5428	76.35	90.0	90.0	89.89	90.29	7.32	1.40	91.45	0.36	12.70	2.54	94.29	95.27	0.98	5.27
	5490	76.47	89.5	91.0	90.55	91.11	3.79	1.40	91.42	0.20	8.98	1.80	95.11	95.27	0.16	5.77
	5527	76.54	90.0	91.0	90.56	91.13	3.83	1.40	91.45	0.22	8.86	1.77	95.13	95.27	0.14	5.27
	5660	76.79	91.0	92.0	90.68	91.26	3.53	1.40	91.53	0.20	9.49	1.90	94.26	94.60	0.34	3.60
	5948	77.33	90.8	90.2	90.83	91.42	3.63	1.40	91.71	0.21	9.50	1.90	94.42	94.60	0.18	4.40
	6028	77.48	91.0	88.0	90.88	91.48	3.58	1.40	91.76	0.20	8.60	1.72	94.48	94.60	0.12	6.60
	6116	77.64	90.7	87.2	90.93	91.53	3.71	1.40	91.83	0.20	8.45	1.69	94.53	94.60	0.07	7.40
	6200	77.80	90.8	89.0	90.98	91.59	3.64	1.40	91.88	0.20	7.76	1.55	94.59	94.60	0.01	5.60
	6285	77.96	92.4	92.0	91.02	91.63	3.81	1.40	91.95	0.21	7.21	1.44	93.07	94.60	1.53	2.60
	6397	78.17	92.5	92.0	91.08	91.69	3.87	1.40	92.02	0.23	8.96	1.79	93.48	93.93	0.45	1.93
	6657	78.66	93.0	92.0	91.23	91.85	4.09	1.40	92.21	0.24	9.08	1.82	93.67	93.93	0.26	1.93
	6723	78.78	92.8	92.0	91.27	91.90	4.22	1.40	92.29	0.25	9.08	1.82	93.72	93.93	0.21	1.93
	6823	78.97	92.0	92.0	91.22	91.83	5.23	1.00	92.25	0.30	8.81	1.76	93.59	93.93	0.34	1.93
	6880	79.08	91.8	91.8	91.08	91.65	6.73	1.00	92.35	0.35	11.68	2.34	93.99	94.07	0.08	2.27
	7128	79.54	93.0	92.0	91.15	91.73	6.90	1.00	92.47	0.36	11.39	2.28	94.01	94.08	0.07	2.08
	7428	80.10	94.0	92.7	91.23	91.83	7.11	1.00	92.61	0.38	11.07	2.21	94.04	94.50	0.46	1.80
	7600	80.42	93.4	93.2	91.30	91.91	7.22	1.00	92.72	0.39	10.90	2.18	94.09	94.50	0.41	1.30
	7800	80.80	93.0	93.0	91.37	91.98	7.37	1.00	92.82	0.40	10.68	2.14	94.12	94.30	0.18	1.30
	8040	81.25	94.0	93.6	91.45	92.07	7.58	1.00	92.96	0.41	10.38	2.08	94.15	94.75	0.60	1.15
	8128	81.41	94.0	94.0	91.48	92.11	7.67	1.00	93.02	0.42	10.25	2.05	94.16	95.00	0.84	1.00
	8300	81.74	94.1	95.5	91.55	92.18	7.87	1.00	93.14	0.44	10.00	2.00	94.18	95.70	1.52	1.60
	8500	82.11	95.2	95.9	91.63	92.27	8.10	1.00	93.29	0.46	9.72	1.94	94.21	96.62	2.41	1.42
	8700	82.49	95.5	97.0	91.72	92.37	8.34	1.00	93.45	0.48	9.44	1.89	94.26	97.00	2.74	1.50
	8756	82.59	96.0	97.6	91.74	92.40	8.46	1.00	93.51	0.49	9.31	1.86	94.26	97.09	2.83	1.09
	8763	82.60	96.0	97.6	91.81	92.46	8.41	1.00	93.56	0.48	9.37	1.87	94.33	97.09	2.76	1.09
Alum Rock	8863	82.79	95.2	97.0	91.99	92.65	8.40	1.00	93.75	0.48	9.37	1.87	94.52	95.20	0.68	0.00
	8916	82.98	96.2	96.2	92.12	92.87	7.78	1.45	94.23	0.51	7.27	1.45	94.32	96.20	1.88	0.00
	8957	83.12	96.5	96.1	92.34	93.08	7.14	1.45	94.23	0.46	7.48	1.50	94.58	96.10	1.52	0.00
	9100	83.62	96.2	96.0	92.89	93.64	7.07	1.45	94.77	0.46	7.26	1.45	95.09	96.00	0.91	0.00
	9230	84.07	96.9	96.7	93.39	94.14	7.02	1.45	95.25	0.46	7.30	1.46	95.60	96.70	1.10	0.00
	9290	84.28	97.0	97.0	93.55	94.29	7.51	1.45	95.56	0.49	7.18	1.44	95.73	97.00	1.27	0.00
	9337	84.45	98.0	97.0	93.08	93.73	12.01	1.45	96.98	0.76	7.66	1.53	96.98	97.10	0.12	0.10
	9387	84.62	98.0	97.4	95.13	95.98	5.85	1.45	96.75	0.30	11.60	2.32	98.30	98.60	0.30	1.20
Sunset	9498	84.80	97.4	97.4	95.94	96.60	5.64	1.45	97.32	0.29	12.02	2.40	99.00	99.30	0.30	1.90
	9559	85.07	97.1	97.4	95.90	96.56	6.23	1.45	97.43	0.38	8.45	1.69	98.25	98.80	0.55	1.70
	9572	85.12	97.1	97.3	95.98	96.66	5.83	1.45	97.43	0.35	8.48	1.70	98.36	98.90	0.54	1.80
	9800	86.07	98.3	98.7	96.46	97.14	6.18	1.45	98.00	0.38	8.10	1.62	98.76	99.20	0.44	0.90
	10000	86.89	99.0	98.4	96.95	97.64	6.45	1.45	98.58	0.41	7.82	1.56	99.20	99.60	0.40	1.20
	10200	87.72	100.0	100.5	97.51	98.22	6.67	1.45	99.22	0.43	7.61	1.52	99.74	100.00	0.26	0.00
	10328	88.25	100.7	101.0	97.90	98.62	6.75	1.45	99.65	0.43	7.54	1.51	100.13	100.70	0.57	0.00
	10456	88.58	102.0	102.0	97.62	98.26	10.41	1.45	100.70	0.62	8.81	1.76	100.70	102.00	1.30	0.00
San Antonio	10556	88.88	102.0	101.5	97.98	98.63	10.31	1.20	100.61	0.61	8.85	1.77	100.61	102.00	1.39	0.50
	10630	89.09	102.0	101.0	99.01	99.85	6.94	1.20	100.75	0.44	7.57	1.51	101.36	102.20	0.84	1.20
	10671	89.20	101.8	101.0	99.51	100.36	5.06	1.20	100.84	0.32	7.78	1.56	101.92	102.48	0.56	1.48
	10884	89.79	101.0	101.7	99.92	100.76	4.57	1.20	101.15	0.29	7.50	1.50	102.26	102.48	0.22	1.48
	11100	90.39	101.5	102.8	100.24	101.05	4.76	1.20	101.47	0.31	5.93	1.19	102.24	102.48	0.24	0.98
	11300	90.94	102.0	103.5	100.57	101.35	4.94	1.20	101.80	0.33	6.35	1.27	102.62	103.15	0.53	1.15
	11519	91.54	105.0	104.2	100.95	101.70	5.11	1.20	102.19	0.34	6.89	1.38	103.08	104.20	1.12	0.00
	11733	92.13	104.0	105.5	101.45	102.18	4.15	1.20	102.50	0.28	6.85	1.37	103.55	104.00	0.45	0.00
	11800	92.32	103.0	104.8	101.53	102.26	4.22	1.20	102.59	0.29	6.76	1.35	103.61	103.90	0.29	0.90
	11900	92.59	102.6	104.5	101.67	102.39	4.31	1.20	102.74	0.29	6.65	1.33	103.72	103.90	0.18	1.30
	12100	93.15	103.3	103.7	101.98	102.67	4.49	1.20	103.05	0.31	6.42	1.28	103.95	104.57	0.62	1.27
	12176	93.36	103.2	103.7	102.10	102.78	4.64	1.20	103.18	0.32	6.58	1.32	104.10	104.57	0.47	1.37
	12300	93.70	103.6	103.8	102.37	103.04	3.91	1.20	103.32	0.25	7.52	1.50	104.54	104.57	0.03	0.97
	12440	94.08	104.0	104.5	102.21	102.84	7.47	1.20	103.88	0.47	5.77	1.15	103.99	105.24	1.25	1.24
I680	12500	94.30	103.4	104.3	101.76	102.30	11.90	1.20	104.94	0.74	8.04	1.61	104.94	105.24	0.30	1.84

[1] Highest Natural Grade w/in R.O.W. or Easment to contain flow.

LOWER SILVER CREEK REACHES 1 THRU 6

HYDRAULIC STABILITY AND SCOUR POTENTIAL FOR PROPOSED CHANNEL IMPROVEMENTS

	Channel Parameters				Design Parameters with Low Roughness							
Location	River Station	Channel Invert (NAVD)	LOB Elev[1] (NAVD)	ROB Elev[1] (NAVD)	1% WSEL (NAVD)	1% Chan Velocity (fps)	10% Chan Velocity (fps)	α	E.G. Elev (NAVD)	Froude Number	Freeboard Line (NAVD)	Energy Grade Contained?
Coyote Creek	73	63.70	84.0	74.0	67.53	18.68	17.84	1.20	74.03	2.33	87.75	YES
	104	64.00	84.0	75.0	69.58	15.95	15.49	1.20	74.32	1.52	87.75	YES
	106	65.00	84.0	75.0	70.44	14.31	13.83	1.20	74.26	1.34	87.75	YES
	200	65.37	85.0	76.0	72.23	11.31	10.72	1.20	74.61	1.00	87.74	YES
	400	66.14	83.2	82.0	72.88	11.66	10.37	1.20	75.41	1.05	87.74	YES
	500	66.53	84.7	82.5	72.65	13.85	11.94	1.20	76.22	1.34	87.74	YES
	600	66.92	85.6	84.2	73.45	13.57	12.72	1.20	76.88	1.24	87.74	YES
	700	67.31	86.8	85.0	74.63	11.93	11.31	1.20	77.28	1.00	86.87	YES
	830	67.82	88.0	86.0	75.44	10.94	10.35	1.20	77.67	0.90	86.53	YES
	860	67.93	88.0	86.1	76.03	9.49	9.39	1.20	77.71	0.78	86.86	YES
	930	68.21	88.0	86.2	76.11	9.88	9.51	1.20	77.93	0.78	87.16	YES
	1025	68.21	89.7	88.5	74.01	17.74	17.06	1.20	79.87	1.53	87.43	YES
	1067	68.74	89.9	90.4	75.68	15.38	14.54	1.20	80.09	1.29	87.30	YES
Wooster	1107	68.90	89.9	90.4	77.90	10.43	9.82	1.20	79.93	0.73	87.46	YES
	1120	68.95	90.0	90.5	77.93	10.47	9.86	1.20	79.97	0.73	87.45	YES
	1148	69.06	86.9	88.5	78.63	8.42	7.99	1.20	79.95	0.57	87.41	YES
	1253	69.47	89.0	88.0	74.92	20.07	18.64	1.20	82.43	1.79	87.36	YES
	1273	69.55	89.1	88.1	74.87	20.79	19.41	1.20	82.92	1.89	87.35	YES
	1350	69.85	88.0	88.4	75.84	20.77	19.89	1.20	83.88	1.70	87.12	YES
	1390	70.00	89.5	89.7	77.29	19.44	18.88	1.20	84.33	1.38	87.15	YES
UPRR	1410	70.08	89.9	89.6	81.76	10.31	9.78	1.20	83.74	0.62	87.35	YES
	1450	70.24	89.9	89.6	81.81	10.35	9.83	1.20	83.81	0.62	87.37	YES
	1525	70.53	89.2	85.0	83.14	6.62	6.35	1.20	83.96	0.39	88.39	YES
	1622	70.91	88.5	85.4	83.31	6.07	5.88	1.20	84.00	0.36	88.46	YES
	1667	71.08	89.6	87.0	83.22	6.86	6.66	1.20	84.10	0.41	87.49	YES
	1763	71.46	89.6	87.0	83.23	7.16	6.99	1.20	84.19	0.44	87.48	YES
	1845	71.78	88.0	87.0	83.26	7.23	6.84	1.20	84.23	0.41	87.77	YES
	1884	71.92	87.8	88.4	82.99	9.52	9.00	1.20	84.68	0.55	87.57	YES
	1885	71.92	87.8	88.4	82.99	9.52	9.00	1.20	84.68	0.55	87.57	YES
Highway 101	2045	72.32	90.1	90.1	83.52	9.39	8.89	1.20	85.16	0.54	88.06	YES
	2046	72.32	90.2	90.2	83.53	9.39	8.88	1.20	85.17	0.54	88.07	YES
	2075	72.42	88.8	90.0	83.88	8.45	8.11	1.20	85.21	0.49	88.22	YES
	2120	72.47	87.2	89.5	84.66	5.16	4.93	1.20	85.16	0.27	89.18	YES
	2220	72.58	86.6	89.6	84.81	4.42	4.24	1.20	85.17	0.24	89.75	YES
	2280	72.65	86.6	89.8	84.76	4.99	4.79	1.20	85.22	0.27	89.74	YES
	2525	72.93	87.8	87.8	84.81	5.10	4.91	1.20	85.29	0.28	89.33	YES
	2625	73.04	88.1	87.6	84.86	4.94	4.78	1.20	85.31	0.28	89.30	YES
	2775	73.21	88.6	88.0	84.99	4.28	4.25	1.20	85.33	0.26	89.11	YES
	3000	73.47	88.0	87.8	85.05	4.18	4.19	1.20	85.38	0.26	89.19	YES
	3200	73.69	88.2	88.8	85.08	4.43	4.42	1.20	85.45	0.27	89.33	YES
	3282	73.78	88.3	88.9	85.10	4.47	4.46	1.20	85.47	0.28	89.36	YES
	3300	73.80	88.0	88.5	85.10	4.56	4.51	1.20	85.49	0.28	89.46	YES
	3500	74.02	88.2	88.0	85.14	4.64	4.61	1.20	85.54	0.28	89.56	YES
	3626	74.16	88.3	88.1	85.17	4.71	4.67	1.20	85.58	0.29	89.62	YES
	3671	74.21	88.0	88.2	85.23	4.34	4.27	1.20	85.58	0.26	89.78	YES
	3771	74.32	88.0	88.3	85.19	4.98	4.88	1.20	85.65	0.29	89.78	YES
Miguelita Creek	3828	74.38	88.2	88.6	84.36	10.70	10.19	1.00	86.14	0.60	89.92	YES
	4100	74.65	89.0	89.0	85.03	9.01	8.94	1.00	86.29	0.49	90.40	YES
	4300	74.85	89.0	89.0	85.08	9.11	9.04	1.00	86.37	0.50	90.47	YES
	4500	75.05	89.0	89.0	85.12	9.21	9.15	1.00	86.44	0.51	90.53	YES
	4700	75.25	89.0	89.0	85.16	9.31	9.26	1.00	86.51	0.52	90.60	YES
	4900	75.45	89.0	89.0	85.20	9.42	9.37	1.00	86.58	0.52	90.66	YES
	5030	75.58	89.5	89.5	85.24	9.47	9.42	1.00	86.63	0.53	90.72	YES
Walgreens	5070	75.62	89.6	90.0	85.24	9.50	9.46	1.00	86.64	0.53	90.74	YES
	5100	75.65	89.6	92.0	85.24	9.52	9.47	1.00	86.65	0.53	90.75	YES
	5105	75.65	89.0	92.0	85.15	9.96	9.99	1.00	86.69	0.57	90.65	YES
	5174	75.77	90.2	92.0	85.17	10.04	10.09	1.00	86.74	0.58	90.66	YES
	5240	75.96	90.4	92.0	85.15	10.37	10.51	1.00	86.82	0.61	90.62	YES
McKee	5428	76.35	90.0	90.0	86.68	10.23	10.15	1.20	88.63	0.60	94.28	YES
	5490	76.47	90.0	91.0	88.29	5.07	5.06	1.20	88.77	0.30	95.11	YES
	5527	76.53	90.5	91.5	88.28	5.39	5.50	1.20	88.82	0.35	95.13	YES
	5660	76.78	90.7	92.2	88.41	4.86	4.93	1.20	88.85	0.31	94.25	YES
	5900	77.23	90.0	92.6	88.46	5.15	5.25	1.20	88.95	0.34	94.39	YES
	6028	77.47	91.5	92.8	88.56	4.88	5.22	1.20	89.00	0.34	94.55	YES
	6116	77.64	91.7	91.7	88.59	5.01	5.48	1.20	89.06	0.32	92.63	YES

LOWER SILVER CREEK REACHES 1 THRU 6

HYDRAULIC STABILITY AND SCOUR POTENTIAL FOR PROPOSED CHANNEL IMPROVEMENTS

	Channel Parameters				Design Parameters with Low Roughness							
Location	River Station	Channel Invert (NAVD)	LOB Elev[1] (NAVD)	ROB Elev[1] (NAVD)	1% WSEL (NAVD)	1% Chan Velocity (fps)	10% Chan Velocity (fps)	α	E.G. Elev (NAVD)	Froude Number	Freeboard Line (NAVD)	Energy Grade Contained?
	6200	77.80	91.2	92.5	88.62	4.99	5.34	1.20	89.08	0.31	94.60	YES
	6437	78.24	92.1	92.1	88.60	5.83	5.99	1.20	89.23	0.38	93.05	YES
	6657	78.65	93.1	92.9	88.67	6.12	6.29	1.20	89.37	0.41	93.56	YES
	6723	78.78	92.5	92.5	88.68	6.34	6.50	1.20	89.43	0.43	93.62	YES
	6823	78.96	92.0	92.3	88.52	7.64	7.68	1.20	89.61	0.49	93.75	YES
	6880	79.07	92.0	92.0	88.30	8.91	8.81	1.00	89.53	0.54	93.96	YES
	7128	79.54	92.7	92.3	88.33	9.29	9.24	1.00	89.67	0.58	93.97	YES
	7428	80.11	94.0	92.5	88.35	9.81	9.82	1.00	89.84	0.63	93.98	YES
	7600	80.44	93.5	93.0	88.37	10.12	10.17	1.00	89.96	0.66	94.01	YES
	7800	80.82	93.0	93.0	88.39	10.53	10.65	1.00	90.11	0.70	94.02	YES
	8040	81.27	94.0	93.5	88.41	11.14	11.35	1.00	90.34	0.76	94.03	YES
	8128	81.44	94.0	93.0	88.42	11.39	14.30	1.00	90.43	0.78	94.05	YES
	8300	81.77	94.0	95.7	88.42	11.99	14.19	1.00	90.65	0.85	94.06	YES
	8500	82.15	95.0	96.2	87.65	14.69	14.06	1.00	91.00	1.15	94.08	YES
	8700	82.53	95.6	97.2	88.16	14.32	13.72	1.00	91.34	1.10	94.11	YES
	8756	82.63	96.1	97.2	88.67	13.40	12.80	1.00	91.46	1.00	94.10	YES
	8763	82.65	98.0	98.0	89.36	11.95	11.36	1.00	91.58	0.84	94.17	YES
Alum Rock	8863	82.84	96.5	97.0	88.23	15.14	15.00	1.00	91.79	1.20	94.36	YES
	8908	82.94	96.0	96.5	89.53	12.51	12.00	1.20	92.45	1.00	94.24	YES
	8908	82.94	96.0	96.5	90.27	10.81	10.43	1.20	92.45	0.83	94.34	YES
	9100	83.61	96.6	96.6	90.66	11.41	11.03	1.20	93.09	0.89	95.08	YES
	9230	84.06	97.1	97.1	89.34	16.98	16.74	1.20	94.71	1.55	95.53	YES
	9325	84.39	97.5	97.5	90.57	16.67	16.39	1.20	95.75	1.56	95.81	YES
	9337	84.43	97.5	97.5	92.71	12.44	11.93	1.20	95.59	1.00	96.18	YES
	9387	84.60	98.0	98.0	95.29	7.28	6.69	1.20	96.28	0.39	97.30	YES
Sunset	9498	84.83	98.0	98.0	95.90	7.03	6.52	1.20	96.82	0.37	97.99	YES
	9559	85.07	98.1	98.1	96.01	6.67	6.39	1.20	96.84	0.42	97.52	YES
	9572	85.12	98.1	98.1	96.11	6.23	5.98	1.20	96.83	0.39	97.65	YES
	9800	86.08	99.1	99.1	96.14	7.04	6.80	1.20	97.06	0.46	98.20	YES
	10000	86.92	98.4	99.3	96.17	7.88	7.69	1.20	97.33	0.53	98.77	YES
	10200	87.76	100.8	100.8	96.21	8.90	8.76	1.20	97.69	0.63	99.42	YES
	10300	88.17	100.7	101.2	96.25	9.45	9.34	1.20	97.91	0.68	99.76	YES
	10349	88.31	100.8	101.3	96.58	8.50	8.19	1.20	97.93	0.58	99.99	YES
	10446	88.58	101.0	102.0	96.15	11.59	10.93	1.20	98.65	0.74	100.10	YES
San Antonio	10556	88.88	102.0	101.2	96.55	11.44	10.80	1.20	98.99	0.73	100.45	YES
	10630	89.08	101.3	101.0	96.82	11.00	11.29	1.20	99.07	0.82	100.57	YES
	10671	89.19	101.4	101.1	98.41	6.66	6.49	1.20	99.24	0.46	101.33	YES
	10884	89.79	101.0	101.5	98.68	6.24	6.16	1.20	99.41	0.45	101.78	YES
	11100	90.39	101.5	105.0	98.76	6.83	6.78	1.20	99.63	0.51	101.86	YES
	11300	90.94	102.3	103.0	98.87	7.43	7.40	1.20	99.90	0.58	102.41	YES
	11519	91.54	104.0	104.2	99.05	8.09	8.05	1.20	100.27	0.65	102.81	YES
	11733	92.13	103.5	105.5	99.73	6.34	6.25	1.20	100.48	0.51	103.34	YES
	11800	92.32	102.3	104.3	99.76	6.56	6.47	1.20	100.56	0.54	103.40	YES
	11900	92.59	102.6	104.6	99.83	6.86	6.78	1.20	100.71	0.57	103.52	YES
	12100	93.15	103.4	104.0	100.00	7.50	7.42	1.20	101.05	0.65	103.79	YES
	12250	93.56	103.8	104.0	100.18	7.94	7.83	1.20	101.35	0.70	104.02	YES
	12350	93.84	104.0	104.0	100.79	6.82	6.49	1.20	101.66	0.56	104.56	YES
(Hydraulic Jump	12450	94.12	104.0	104.0	98.38	18.59	17.39	1.20	104.82	2.16	104.58	NO
	12500	94.26	108.0	110.0	100.82	14.59	13.95	1.20	104.79	1.00	104.85	YES
I680	12794	94.15	110.0	110.0	105.05	8.78	8.36	1.00	106.25	0.47	107.39	YES
	12795	94.15	110.0	110.0	105.05	8.78	8.36	1.00	106.25	0.47	107.39	YES
	12829	94.20	108.2	106.3	105.25	8.10	7.72	1.00	106.27	0.43	107.64	YES
	12880	94.34	107.3	105.8	105.99	4.79	4.60	1.00	106.35	0.25	110.13	YES
	13013	94.72	107.5	106.7	105.98	4.97	4.79	1.00	106.36	0.27	108.29	YES
	13035	94.78	107.5	106.7	105.92	5.48	5.25	1.00	106.39	0.29	108.35	YES
Jackson	13125	95.05	107.5	106.7	106.63	5.27	5.15	1.20	107.15	0.27	110.82	YES
	13126	95.05	107.5	106.7	106.62	5.38	5.26	1.20	107.16	0.28	110.81	YES
	13210	95.30	107.2	106.2	106.69	5.15	5.16	1.20	107.18	0.28	110.95	YES
	13300	95.57	107.2	106.3	106.70	5.28	5.31	1.20	107.22	0.30	110.04	YES
	13400	95.87	106.9	107.0	106.71	5.44	5.49	1.20	107.26	0.31	110.14	YES
	13500	96.17	107.8	107.6	106.72	5.61	5.68	1.20	107.31	0.32	109.21	YES
	13600	96.47	107.8	107.7	106.73	5.79	5.89	1.20	107.35	0.34	109.29	YES
	13700	96.77	108.3	108.2	106.75	5.98	6.11	1.20	107.42	0.36	109.38	YES
	13800	96.77	109.3	109.0	106.80	5.95	6.05	1.20	107.46	0.35	109.56	YES
	13900	97.07	109.9	108.5	106.82	6.14	6.27	1.20	107.52	0.37	109.67	YES

COYOTE WATERSHED PROGRAM
LOWER SILVER CREEK IMPROVEMENTS
TRACTIVE FORCE ANALYSIS

Reach:	Coyote Creek to Highway 101	Highway 101 to Reach 2	Reach 3A	Reach 3D	Reach 3E&F	Reach 4B	Reach 4C	Reach 5	Reach 6A	Reach 6B
d_{90} (mm)	1.5	2.60	0.01	0.03	0.2	0.6	0.6	0.3	0.4	0.4
2-year Q	940	940	810	780	780	780	780	680	610	610
T.W.	52	50	48	38	38	49	21	21	21	56
q	18.1	18.8	16.9	20.5	20.5	15.9	37.1	32.4	29.0	10.9
n	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
depth	3.5	3.6	3.5	3.3	4.0	3.0	3.8	4	3.5	2.75
S_{EG}	0.0040	0.0007	0.0015	0.0035	0.0025	0.0030	0.0032	0.002	0.0009	0.0025
U_*	0.67	0.28	0.41	0.61	0.57	0.54	0.63	0.51	0.32	0.47
R_*	330	243	1	6	37	106	123	50	42	62
K_s	0.058	0.056	0.12	0.035	0.037	0.046	0.047	0.04	0.038	0.041
S_{eq}	5.9337E-05	1.1973E-04	1.3846E-07	9.6728E-08	1.5741E-06	1.2834E-05	6.4017E-06	2.1246E-06	3.2687E-06	8.4456E-06
$S_{initial}$	0.0039	0.0011	0.0019	0.0035	0.0028	0.003	0.0033	0.002	0.001	0.0033
Max. Unprotected L	1800	1675	1450	800	1150	2350	1380	1600	1700	1300
Max Degredation	6.9	1.6	2.8	2.8	3.2	7.0	4.5	3.2	1.7	4.3
Spacing for 3' Deg.	781	N/A	N/A	N/A	1072	1004	911	1502	3010	911
			Total Degradation at 680 is 2.8' + 3.2' = 5.0'							
						Total Degradation at Moss Point is 3.2' + 1.7' = 4.9'				
							Total Degradation at Cunningham is 1.4' + 4.3' = 5.7'			